

SCIENCE ABSTRACTS.

PHYSICS AND ELECTRICAL ENGINEERING.

JANUARY 1902.

GENERAL PHYSICS.

1. *Air-pumps.* G. W. A. Kahlbaum. (Ann. d. Physik, 6. 8. pp. 590-602, Nov., 1901.)—This paper contains a useful account of improvements made during the past ten years in the construction of air-pumps of the Sprengel type. Numerous references are given to the author's communications on the subject throughout that time, and also to those of H. Boas, A. Raps, K. Kiss, W. Donle, S. P. Thompson, and others. Of the many kinds of this type now invented the author has examined 150, and has determined their respective merits. The mean performance of the thirty that came first to hand is indicated by the following figures, which show the time occupied in producing a diminution of pressure in a volume of 500 c.c. :—

8 minutes	0.500000 mm. of mercury.
15 " 	0.000165 " "
80 " 	0.000069 " "

Some interesting figures are given with regard to the maximum degree of vacuum that can be attained. Comparing piston pumps with Sprengel pumps, Neesen with the former in seventeen hours reduced the pressure to 0.000079 mm.; with the latter in five hours he reduced the pressure to 0.000091 mm.; but he does not state the volumes operated upon.

The absence of water vapour is of first importance in attaining these low pressures, and although a drying-tube has the objection of increasing the volume, its advantages outweigh this consideration, at any rate for a well-constructed pump. Speed of operating depends upon the proper adjustment of the proportionality of afflux to the escape of mercury in the tube, and this matter should not be left to the judgment of the glass-blower. When this is attended to, the figure, as above, comes down to the order 0.000002 mm.

In pumps of the Sprengel type the friction of the falling drops of mercury causes electrical discharges to take place in the tube, the effect of which is to erode the glass, and finally to interrupt the working. This question is discussed, and the author shows how it can be obviated by the use of a steel gun-barrel fall-tube. Using all improvements, the author obtained a vacuum of 0.0000018 mm., which is probably the best on record. In order to make glass taps air-tight a substance called *flomenfell*, prepared by Kress & Co., of Heilbronn, is recommended.

R. A.

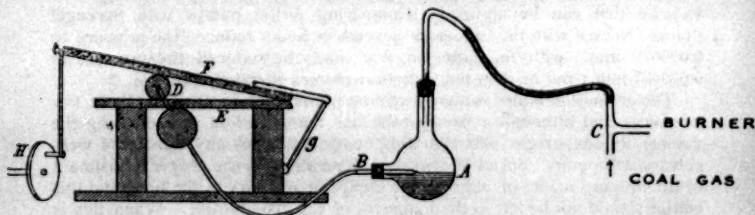
2. *Glass cocks for Gas Analysis.* **H. Thiele** and **M. Eckardt.** (*Ann. d. Physik*, 6. 2. pp. 428-481, Oct., 1901.)—Various cocks are described in which special precautions are taken to make them trustworthy for gas analysis work. A perfect arrangement should afford an effective cut-off from external air, and also from any gas that might tend to pass by way of the hole in the conical stopper. As regards ensuring against the admission of external air, this can be done by submerging the cock in mercury; for this purpose it is convenient to hollow out a cork to form a mercury jacket. Oblique boring of the hole in the stopper is of advantage, as it makes more difficult the capillary paths scored around the cone in the process of grinding. Another method of avoiding the effects of these capillary leaks is described by Göckel (*Zeitschr. für angew. Chemie*, p. 1288, 1900). He uses a hollow cone plug stopper with two or more holes drilled in the same straight line along a side. The plug is always horizontal and is half filled with mercury. The inlet and outlet tubes are parallel to one another, and are both at the top of the horizontal stopper, forming with it a double T-joint when the corresponding holes in the hollow plug are in the "up" position. When these holes are in the "down" position the tubes are cut off from one another, and the holes in the plug are effectively closed by the mercury contained in the plug. This mercury works its way into the capillary scorings, and makes a good cut-off. A drawing is given of an arrangement in which ground surfaces are dispensed with, the gas being shut off by mercury surfaces throughout, in a system of glass tubes, forming an air-trap.

R. A.

3. *Cutting Glass.* **G. Roy.** (*Journ. de Physique*, 10. pp. 614-615, Oct., 1901.)—The author uses a thermocautery for guiding a crack in glass; the glass is touched just beyond the existing end of the crack. Cracks can be turned almost at right angles.

A. D.

4. *Apparatus for Producing Coloured Flames.* **Stscheglayew.** (*Zeitschr. Phys. Chem.* 39. pp. 111-113, Nov. 12, 1901.)—The apparatus figured, for obtaining steady, uniformly coloured flames, is described in the belief that it will materially assist the investigation of such problems as are presented by



the electromotive forces and electric conductivity of flames. A blast of air obtained by compressing the rubber bulb D about 450 times a minute by the aid of a water, or electric, motor, is driven through a narrow tube B into the surface of the solution in A, so that a steady spray passes to the burner.

D. H. J.

5. *Optical Measurement of Length Standards.* **A. Pérot** and **C. Fabry.** (*Annal. Chim. Phys.* 24. pp. 119-139, Sept., 1901.)—The authors give details

of special means which they have devised for applying the interferential method to the determination of the absolute length of standard bars, the system adopted depending on the form of the end of the bar. Many kinds of standard bars are not suitable for the direct application of optical measurements, and in these cases an intermediary mechanical adjustment is fitted to one of the mirrors of the interferometer, the connection of which with the standard bar under examination is regulated by linkwork, so as to be under a known degree of pressure. This pressure is varied, and the resulting deformation plotted, so that, by a slight extrapolation, the length corresponding to zero pressure is obtained, this being presumably equivalent to that which would have been determined if the optical measurement had been direct. Sketches of the modifications utilised for this purpose, and for the maintenance of uniform temperature, are given in the paper. C. P. B.

6. *Distillation of Metals.* **G. W. A. Kahlbaum.** (Phys. Zeitschr. 8. pp. 32-37, Oct. 15, 1901. Paper read before the 78rd Naturforscherversammlung at Hamburg.)—The author has distilled Se, Te, K, Na, Li, As, Sb, Bi, Mg, Ca, Sr, Al, Th, Zn, Cd, Cu, Ag, Au, Ni, Fe, Cr, Zr, Pb, and probably also Sn. Difficulties arising from the want of transparency of porcelain vessels have been overcome by the use of Röntgen rays. The highest temperature which it was safe to use with the apparatus was 1450° (protracted distillation in a vacuum). Under extremely heavy pressures the specific heats of the distilled metals fell very slightly; the densities first increased, the more so the lighter the deposit had originally been, and then very slightly decreased as the pressure was continued. [See also Abstract No. 1818 (1900).] A. D.

7. *Effect of Drawing on Elasticity of Copper Wire.* **J. R. Benton.** (Phys. Rev. 13. pp. 234-245, Oct., 1901.)—If a copper wire is first annealed by heating electrically to redness, and is then drawn, its modulus of rigidity decreases, and Young's modulus increases. Each successive drawing causes a further diminution of the modulus of rigidity, and a further increase of Young's modulus, the amount of change for each modulus becoming less with each drawing. If the wire is finally annealed, after having been drawn several times, the modulus of rigidity returns to a value considerably greater than its original one, and Young's modulus to one considerably less than its original value. Probably the difference in elastic properties between the wires annealed before drawing and those annealed after drawing is due to the fact that the latter cooled from red heat more rapidly, on account of their smaller diameter, and were therefore more completely annealed. The value of Young's modulus determined by the method of bending proved to be considerably less than that obtained by extension; but for the annealed wire the values obtained by the two methods very nearly agree. The greater stiffness of drawn wires as compared with annealed wires, which has been often observed, must therefore be due simply to the increase in the *limit* of elasticity. The author gives a full description of his methods, and an analysis of the possible errors, and expresses his results both in tables of numerical values and by plotted curves. W. C. H.

8. *Boyle's Law at very Low Pressures.* **A. Battelli.** (Phys. Zeitschr. 8. pp. 17-21, Oct. 15, 1901.)—The author has repeated and confirmed his former observations [see Abstract No. 1086 (1901)], and has carefully investigated the question as to whether the changes observed were due to absorption by the walls of the containing vessels. He used both glass and iron apparatus.

Carbonic anhydride appears to be more compressed than Boyle's Law would indicate, but this is due, in part at least, to absorption by the walls of the vessel containing the gas. With air, oxygen, and CO_2 there are marked departures from Boyle's law. In the case of hydrogen there is absolutely no absorption, whether glass or iron vessels are used. With air and carbonic anhydride a small absorption is noticed, beginning at a pressure of 1 mm. in glass vessels. The absorption is quite distinct in the case of carbonic anhydride. The following are the principal results of the investigation:—(1) Hydrogen follows Boyle's law from about 1 atmosphere to 0.02 mm. pressure. (2) Air varies from the law between 2 and 5 mm. (3) Oxygen shows a break in the continuity of its behaviour at about 0.7 mm. (4) Carbonic anhydride is more compressed with small pressures than Boyle's law would indicate; and this phenomenon is probably due to absorption by the walls of the vessel containing the gas.

On the kinetic theory of gases the collisions which take place may give rise to the formation or dissolving of more or less complex molecular groups, and the molecular force of cohesion, on which the formation of these groups depends, may lead to various changes. J. J. S.

9. *Supposed Anomaly of Oxygen at Low Pressures.* **M. Thiesen.** (Ann. d. Physik, 6. 2. pp. 280–301, Oct., 1901.)—Bohr had stated that oxygen deviated strongly from Boyle's law at a pressure of 0.7 mm., and this statement had more or less been confirmed by Battelli, Baly and Ramsay, and others. The author discusses these experiments, especially those of Bohr and of Battelli, and finds that their results do not really agree. Thiesen himself employs the same apparatus in which he studied the behaviour of water vapour. Three balloons, the first two each of 10 litres, the third of 0.8 litre capacity, are connected in series; the oxygen is generated by heating mercuric oxide. To test the influence of large surfaces, the third balloon was afterwards stuffed with glass wool. Certain peculiarities were noticed in the latter case, but there seems to be no reason for assuming any anomaly at 0.7 mm. pressure. H. B.

10. *Internal Friction of Helium.* **H. Schultze.** (Ann. d. Physik, 6. 2. pp. 302–314, Oct., 1901.)—With helium purer than that used by Rayleigh, but still containing 1.25 per cent. of neon, the author obtains values of η about 10 per cent. above Rayleigh's (1.086 that of air at 15°C ., Rayleigh's being 0.96). At temperatures $15^\circ 3$, $99^\circ 6$, and $184^\circ 6$ the values of η are respectively 1969, 2348, and 2699 times 10^{-7} ; whence $\eta_0 = 1891 \times 10^{-7}$, and $C = 80.3$, while in the formula $\eta_\theta = \eta_0(1 + c\theta)^n$, n has values between 0.6852 to 0.6771, as against Rayleigh's $n = 0.681$. In the values of η there were variations of 1 per cent., 1891×10^{-7} , which are at present unaccounted for, but which seem to be related to the time elapsed since previous testings. A. D.

11. *Lines and Planes of Closest Fit.* **K. Pearson.** (Phil. Mag. 2. pp. 559–572, Nov., 1901.)—The author points out that in nearly all the cases dealt with in the text-books on least squares, one of the variables is selected as the independent variable, and the line or plane of closest fit thus obtained depends on the variable selected, and then proceeds to consider the general problem of finding the line or plane which will be the "best fit" to the system of points obtained by plotting the observed variables, all subject to error, in plane, three-dimensioned or higher space, as may be most suitable to the physical, statistical, or biological problem in question. The "best fit"

is taken to be that which makes the sum of the squares of the perpendiculars on the line or plane a minimum. The analogy with the problem of finding moments of inertia then shows that the line or plane required passes through the centroid of the system of points. A complete analytical solution is next given of the problem of finding the "best-fitting" plane, which, when geometrically interpreted, leads to the result that the "best-fitting" plane is perpendicular to the greatest axis of a certain ellipsoid, the ellipsoid of inertia in the analogue, and the minimum mean square residual varies inversely as the length of this axis. The author calls this the *ellipsoid of residuals*, since the inverse square of its radius measures the square of the mean square residual. It is then shown that the line which fits best a system of n points in q -fold space passes through the centroid of the system, and coincides in direction with the least axis of the ellipsoid of residuals. The author then proceeds to express the properties of the "best-fitting" plane and line in terms of the correlation ellipsoid, but points out that the investigation shows that the q directions of independent variation, and the standard deviations of the independent variables, may be found from the ellipsoid of residuals, which will usually be arithmetically simpler. The paper concludes with some arithmetical examples of applications of the process.

G. W. DE T.

12. *Form of Rifle Bullets.* **E. Lampe.** (Deutsch. Phys. Gesell., Verh. 8. 12. pp. 151-162, 1901.)—The surface of the bullet must be a surface of revolution, the axis of which is assumed to coincide with the tangent to the path of the centre of gravity. The resistance of air at constant velocity, perpendicular to a plane, per unit of its surface, is denoted by W_0 . If the direction of motion of the bullet be that of negative x , the resistance of that part of the surface of revolution which lies between the ordinates y_1 and y_2 is—

$$W = 2\pi W_0 \int_{y_1}^{y_2} dy y / \left\{ 1 + \left(\frac{dx}{dy} \right)^2 \right\}$$

The integration is effected for surfaces of the second order, especially the hyperboloid of revolution, for which numerical results are calculated. The writer points out an error into which August had fallen, and its correction by Armanini. He also refers to a proof by Kneser that the Newtonian surface of least resistance leads to a minimum resistance in the present problem. The necessary corrections of August's numerical tables are then given. The paper concludes with an example of the mathematical treatment of hyperboloidal functions. [See also Abstract No. 2828 (1901).]

S. H. B.

13. *On the Breaking of Waves.* **W. G. Fraser.** (Phil. Mag. 2. pp. 356-361, Oct., 1901.)—According to the ordinary theory of waves in water, applicable in strictness only to small disturbances, a wave reaching an obstacle, such as a wall, is reflected, the two systems of original and reflected waves coexisting. It is found, however, in fact, that large waves instead of being reflected, or wholly reflected, break into spray at the obstacle. And this is the phenomenon which the author seeks to explain.

The explanation given is that the vertical component of velocity is checked by the obstacle, and this tends to produce variation of density, and, if that goes beyond a certain point, breach of continuity. He considers three cases: (1) Waves in deep water with direct incidence; (2) the same for

waves in shallow water; (8) oblique incidence. If u be the horizontal velocity of an element, v the vertical velocity, so that $u = \frac{d\phi}{dx}$, $v = \frac{d\phi}{dy}$, the author proposes to substitute mv for v , where m is a very little less than unity. That is inconsistent with the equation of continuity unless there be compression. For case (1) of deep waves, it is found that, η being the amplitude and λ the wave-length, the cohesive forces will suffice to prevent rupture of continuity so long as η/λ does not exceed a certain small amount. The result for case (2), that of shallow water, is of the same general character. For case (8), not only the vertical component of velocity, but also the horizontal component parallel to the obstacle is checked, and requires to be affected by a factor n , corresponding to m above. The result is that α being the angle of incidence, the wave will break if $\eta \cos^2 \alpha / \lambda$ exceeds a certain small amount. S. H. B.

14. *Laws of Viscosity.* L. Natanson. (Phil. Mag. 2. pp. 342-356, Oct., 1901. Translated from the Akad. Sci. Cracovie, Bull. Feb., 1901.)—The theory of relaxation after strain, originally due to Poisson, has been developed by Stokes and Maxwell. Poisson's ideas, in the view of the present writer, are very important, and lead to a generalised theory of viscosity, of which the accepted theory is a particular case. Natanson starts with the consideration of a perfectly continuous and isotropic fluid, and, employing the usual notation and the classic theory of elasticity, he obtains equations of the types—

$$p_{xx}^0 - p_0 = -2n\epsilon^0 - (k - \frac{2}{3}n)\Delta^0,$$

and—

$$p_{yz}^0 = -n\alpha_0,$$

in which n is the modulus of rigidity, k the modulus of compressibility, and p_{xx} , &c., denote normal pressures, p_{yz} , &c., the corresponding tangential pressures, and p_{xx}^0 indicates the value of p_{xx} at an initial instant when $t=0$. Also Δ is the cubic dilatation, ω its rate of increase per unit of time, and $\epsilon = dx/dx$, ϵ denoting displacement in the direction x . It is supposed that at a given instant a certain deformation is impressed on the fluid. The system being left to itself, this distortion will gradually disappear by the process of relaxation. A hypothesis is now made that the laws of relaxation may be expressed as follows:—

$$\frac{dp_{xx}}{dt} = -\frac{p_{xx} - p}{T}, \quad \frac{dp_{yz}}{dt} = -\frac{p_{yz}}{T},$$

where T is the "time of relaxation," a constant characteristic of the medium, and p is the normal pressure, uniform in all directions, which would exist in the undistorted medium. The above values for dp_{xx}/dt , &c., lead to equations of the form $dp/dt = -h\omega$ where h is a constant. This is the same result as we should obtain from the hypothesis that the pressure does not vary when $\omega=0$; and this, as shown, leads to h being equal to k . It appears probable that this relation, $h=k$, holds absolutely, or very approximately, for all fluids in nature, so that $dp/dt = -k\omega$ may be taken as the law of relaxation. It involves the existence of a relation between the pressure p , the density ρ , and the temperature θ of the form $p = p(\rho\theta)$.

A distinction is now drawn between the *true* and the *apparent* deformations of the fluid. The symbols ξ , η , ζ , usually employed to express displacements, relate to those displacements which are evident to our senses, which can in fact be measured. But deformations affecting portions of the fluid too

small for observation may exist, and their physical consequences may be all-important. The hypothesis now made is that Hooke's law extends to fluids, but has to be applied, not to the components of the apparent deformation, but to those of the actual deformation.

Developing the mathematical theory, Natanson introduces two new constants, λ , μ , connected with the constants k and n of the classical theory by the relations—

$$\begin{aligned} nT &= \mu, \\ (k - h - \frac{2}{3}n) &= \lambda. \end{aligned}$$

These are in his theory the two coefficients of viscosity. Stokes, Maxwell, and others have concluded that $\lambda = -2/3 \cdot \mu$. Voigt, on the other hand, calls in question the existence of any relation between the two constants. The writer suggests that some indication of the value of the ratio λ/μ may perhaps be obtained by calculations of the Rayleigh Dissipation function. Natanson says, in conclusion, that the relations $h = k$, and $\lambda = -2/3 \cdot \mu$, though consistent with, are not essential to, his theory of viscosity. S. H. B.

15. The Mechanism of Radiation. J. H. Jeans. (Phil. Mag. 2. pp. 421-455, Nov., 1901. Paper read before the Physical Society of London, June 14, 1901.)—Jeans considers in this paper certain hypotheses concerning the structure of molecules and atoms by which the phenomena observed in the spectroscopy may be explained. The radiation emitted by a gas is supposed to be made up of contributions from a great number of vibrators. It is shown that if each vibrator were capable of rotation about an axis through its centre with an angular velocity ϕ , and if that axis were itself rotating with an angular velocity ω , there would be a spectrum consisting generally of a bright line and a luminous band. If there is to be a line spectrum only, it is found that ω must, on an average, be very small compared with ϕ . From considerations of the law of equal partition of energy [here assumed to be true in fact] Jeans arrives at the conclusion that the atom, and not the molecule, is the vibrator—the exception being the case of monatomic gases, for which, the author says, the law of equal partition fails, and ω is very small. It is inferred that the vibrators, in all gases giving line spectra, are dissociated atoms, and approximately spherical in form—an hypothesis which would explain the fact that pure line spectra are given only by elements. Jeans then considers the structure of an atom as consisting of a great number of point electric charges arranged in spherical shells of alternate signs, the outer shell being always negative. This is assumed to account for the greater importance of negative ions, as shown by Zeeman and others. The mathematical theory of the vibrations of such an ideal atom is worked out *in extenso*, on the assumption of a potential of the form $\rho\rho'\chi_1(r) + \sigma\sigma'\chi_2(r)$ between two charges ρ , ρ' , with densities of matter, σ , σ' at distance r , where, as r increases, $\chi_1(r)$ becomes $\frac{1}{r}$, and $\chi_2(r)$ vanishes compared with $\chi_1(r)$. The spectrum of such an ideal atom is discussed. Incidentally the calculations lead to an estimate for the size of an atom; namely, the radius of an atom of atomic weight n should be, at least as regards order of magnitude, $n^{1/3}10^{-9}$ cm. The author then considers how far the spectrum of the real atom may be expected to differ from that of the ideal one.

After some discussion of the Zeeman and Doppler effects, he passes on to consider the structure of the molecule. An atom may consist of $n + s$ positive, and n negative ions, each having a charge e , and s being very small

compared with n , so that at sufficient distances the atom behaves as a point with charge se . Such atoms may combine to form a molecule, this being defined as a system of ions of which the total charge is zero. From this hypothesis it follows that no free ions can be liberated by chemical change. Also that the force exerted by a molecule at external points falls off very rapidly with the distance. Electrostatically there will be a potential of the form $V = \frac{a_0}{r} + \frac{S_1}{r^2} + \frac{S_2}{r^3} + \&c.$, where $S_1, S_2, \&c.$, are spherical surface harmonics of orders 1, 2, &c., and a_0 is proportional to the "valency" of the atom.

Since by the "integral normal" theorem, $\int 4\pi r^2 \frac{dV}{dr} dS = -4\pi se$, the result is deduced that a_0/r corresponds to the chemical force between atoms. Between molecules the force will be represented by the subsequent terms in the expression for V . Each molecule will have, generally, a rotational vibration about an axis, which will emit electromagnetic waves. Under certain circumstances this may be converted into continuous rotation, the atom or molecule thus becoming a permanent magnet amenable to Weber's theory. Finally the theory is applied to specific inductive capacity, dielectrics, conductors, and electrolytes.

S. H. B.

18. *The Geodynamic Section of the Ximénian Observatory at Florence.* **P. Alfani.** (*Rivista Sci.-Industriale*, 88, pp. 98-102, 1901.)—The paper, which is a reproduction of one published in the seismological journal of the observatory, describes the microseismographs, seismoscopes, and seismographs collected together in the underground chamber, used in connection with the observatory, for the exact observation and measurement of earth tremors.

D. H. J.

17. *Seasonal Variation of Temperature in the British Isles.* **W. N. Shaw** and **R. W. Cohen.** (*Roy. Soc., Proc.* 69, pp. 61-85, Nov. 8, 1901.)—The harmonic analysis of the curves of mean atmospheric temperature based on the records of the Kew, Aberdeen, Falmouth, and Valencia observatories for the years 1871 to 1895, shows that the primary solar variation is compounded with a secondary half-yearly meteorological variation. This secondary effect, having its maxima in February and August, and its minima in May and November, oscillating in different years over the first ten days of each of these months, moderates and lengthens the winter and intensifies and shortens the summer. The secondary effect is independent of the relative frequencies of cyclonic and anticyclonic weather, but partly due to a periodic variation in the relative frequency of the winds grouped as cold (E., N.E., and N.), moderate (S.E. and N.W.), and warm (W., S.W., and S.) respectively; it differs in magnitude for the several stations, and is not found in the purely Continental stations of Vienna and Agra. A similar effect is observed in the variation in the magnitude of the barometric gradients between London and Aberdeen, and between London and Valencia, and further in the curves of sea-water temperature. The effect of the sea-water can be estimated by the geometrical composition of the harmonic curves, but we have so far very few data. The sea effect would delay all the seasons, and increase the amplitude of the temperature oscillations. As the temperature range of the ocean is small, however, and as its maximum lags considerably behind the planetary effect, these conclusions do not affect the common rule that coast stations enjoy a more equable climate than Continental stations.

H. B.

18. *Solar Radiation*. **J. Y. Buchanan**. (Nature, 64, pp. 456-459, Sept. 5, 1901.)—The author gives a general review of the conditions affecting the distribution and retention of the heat received from the sun, with comparative measures at various stations, obtained by different methods. He concludes that the higher values approaching "4" for the "solar constant" are much too high, and suggests a value about 1.7-1.8 grm.-calories as representing the best modern determinations. [See also Abstract No. 881 (1901).] C. P. B.

19. *Spectrum of η Argus*. **D. Gill**. (Roy. Soc., Proc. 68, pp. 456-458, Sept. 12, 1901.)—The paper gives a table of the lines measured in the spectrum of η Argus, obtained with the McClean telescope and a slit spectrograph. The spectrum is stated to resemble that of Nova Aurigæ. The photograph used for the reduction was obtained on the nights of April 14, 15, 16, 17, 1899, with a total exposure of 6 h. 10 m. On the same plate a comparison spectrum of the spark of iron was also photographed. The measured wave-lengths of the lines in the spectrum of η Argus are tabulated in conjunction with those observed in the spectrum of Nova Aurigæ. A photograph obtained with an object-glass prism spectrograph is also reproduced, and the derived wave-lengths are given. C. P. B.

REFERENCES.

20. *Spectrum of Nova Persi*. **J. N. Lockyer**. (Roy. Soc., Proc. 69, pp. 183-187, Nov. 19, 1901.)—Details are given in regard to the changes of the spectrum up to September 30, with a discussion of the probable chemical origin of the lines recorded. C. P. B.

21. *Spectrum of Nova Persi*. **W. S. Adams**. (Astrophys. Journ. 14, pp. 158-166, Oct., 1901.)—The paper gives in detail the observed changes in the spectrum of the new star during the earlier part of its appearance. C. P. B.

LIGHT.

22. Calibration of a Spectrometer Circle. V. H. Velej and J. J. Manley. (Ann. d. Physik, 6. 8. pp. 575-579, Nov., 1901.)—The authors describe two simple methods, one of which requires only the aid of two plumb-lines, with the plummets immersed in colza oil to keep them steady. The circle being placed horizontally, the plumb-lines are hung about 5 m. off, so that in ground plan the distance between them subtends an angle of 80° at the centre of the circle. A definite interval of the circle, say that between division 150° and division 180° , is chosen as the standard, the telescope is clamped to the circle, and the distances are adjusted until one plumb-line is seen on the cross-wires when the circle-pointer reads 150° , and the other when the pointer reads 180° . Any other nominal interval of 80° of the circle can then be compared with the standard interval. In the other method the circle telescope does not come into play. A small mirror is fixed on the central table, directly over the axis of rotation. Two small telescopes, A and B, are mounted at distances of about 1.5 m. from the mirror, and from each other, and pointing directly towards the mirror. Their axes produced will thus form an angle of about 60° at the mirror. Telescope A has a fine cross X in front of the object glass. Telescopes and mirror are adjusted so that the reflection of the cross X is on the cross-wires of A when the pointer attached to the central table reads 150° , and on the cross-wires of B when the pointer reads 180° . On clamping the telescopes, and revolving the circle, any interval can be compared with the standard one as before. The author found an average difference of $6''$ in an interval of 80° . The errors were sufficient to affect an observation of refractive index to the 5th or 6th decimal place.

A. E.

23. New Interference Photometer and Pyrometer. O. Lummer. (Deutsch. Phys. Gesell., Verh. 3. 11. pp. 181-147, 1901.)—Herschel's fringes are utilised in this instrument, the essential part of which is a cube formed by placing two right-angled prisms with their hypothenusal bases vertical, and in contact except for a thin layer of air. The observer, looking into one face of the cube with a weak telescope, views the luminous surface under examination directly through the cube, and the comparison surface by reflection at the base of the nearer prism. This comparison surface consists of a translucent disc, placed on one side, with a lamp behind it. The light bands of the transmission fringes coincide with the dark bands of the reflection fringes, and when the two sources are equally bright the fringes vanish. Hence, by the aid of Nicol's prisms, or other contrivances for reducing brightness, the surface under examination may be compared with the standard surface. An advantage of the method is that the fringes in the neighbourhood of total reflection are achromatic, and exceedingly sharp and fine. Several pages are devoted to a discussion of Herschel's fringes, which the author has before shown to be identical with the fringes of a plane plate in parallel light. Formulæ are given for finding the number, position, &c., of the bands. A drawback to all previous photometers is that the comparison object is at a finite distance. Herschel's fringes lie, theoretically speaking, at infinity, yet in actual naked-eye observation they appear on the face of any object viewed

through the cube. When a small telescope is used, the bands and the object viewed will both appear distinct if the latter is at more than 8 m. distance. Thus the instrument can be used for exploring the distribution of brightness in space. In employing the instrument as a pyrometer, recourse must be had to curves showing the connection between temperature and photometric energy. These have been discussed by the author and Pringsheim [see Abstract No. 1290 (1901)], who find that the form of the curve is similar for all opaque bodies. For high temperatures, large errors of observation will make little difference in the result. The author has not yet been able to put his apparatus to a practical test. A. E.

24. *Action of Light on Metallic Surfaces.* H. Buisson. (Journ. de Physique, 10. pp. 597-607, Oct., 1901. Ecl. Électr. 29. pp. 7-15, Oct. 5, 1901.)—When a metallic surface is illuminated by sunlight, the rate of loss of negative electric charge steadily falls, until at length the surface becomes in this respect insensitive. Amalgamated zinc can have its surface frequently and uniformly renewed by simply rubbing it with rag or paper. In the dark this change to an insensitive condition does not occur, and the sensitiveness of a fresh surface is even increased, sometimes very considerably, by keeping it for a few hours in darkness. The insensitiveness produced by the light is not permanent, and slowly but completely disappears in darkness. Under the same radiations, a metal becomes more negative by from 0.10 to 0.14 volt, with the exceptions of nickel, which is very slightly affected, and platinum, which is oppositely affected. This modification is not permanent; it disappears gradually and completely in the dark, and under the continued action of light it reaches a limit after a few minutes. The ultra-violet radiations in sunlight play a feeble part in this; those in the arc-light seem to act in a contrary sense to the visible rays, particularly the green and blue, there being a maximum in the violet, beyond which there is inversion in the case of most metals. The variation is independent of the nature of the surrounding gas and of its pressure. Amalgamated zinc, exposed under a photographic negative in sunlight, can afterwards be developed by iodine vapour, Daguerrotype-fashion; the parts protected from the sunlight are the most attacked. The change produced by light is entirely superficial, and does not affect a thick enough layer to enable any effect to be produced upon the state of polarisation of a reflected beam of light. Probably the change of condition is determined by an equilibrium between the surface of the metal and the closely adhering film of gas, probably oxygen, since the metallic surfaces were prepared in air. [See also Abstract No. 1630 (1900).] A. D.

25. *Asigmatic Image of a Horizontal Plane under Water.* L. Matthiessen. (Ann. d. Physik, 6. 2. pp. 847-852, Oct., 1901.)—The paper contains a full investigation of the two sets of caustic curves for an eye in a fixed position, and the form of the two resultant images. A. D.

26. *Test Diagram for Stereoscopic Vision.* C. Pulfrich. (Zeitschr. Instrumentenk. 21. pp. 249-280, Sept., 1901.)—The diagram, which is meant to be placed in a stereoscope, consists of a pair of circles about 2 inches in diameter, each containing a printed inscription and a series of small geometric designs. It is primarily intended to provide observers using the author's stereoscopic apparatus [see Abstract No. 2094 (1901)] with a means of measuring their capabilities as regards estimation of stereoscopic depth. The

author claims that the diagram may also serve an educational purpose in training children and others to use both eyes alike, and to form correct ideas of space from binocular vision. A. E.

27. Colour Vision ("Areal Induction"). G. J. Burch. (Roy. Soc., Proc. 60, pp. 125-133, Nov. 19, 1901.)—The paper deals chiefly with the explanation of a phenomenon recently described by Bidwell [see Abstract No. 2344 (1901)]. In what is called the "black-spot experiment," a disc of green light is flashed on a screen (or directly on the retina), and followed by a somewhat larger disc of white light with a black spot in the middle. The cycle is completed by an interval of darkness, and then recurs. The impression produced is that of a purple disc with a perfectly black spot in the middle, showing that in the spot area the response to the first (green) stimulus is blocked, or "inhibited," by a second stimulus falling upon a neighbouring part of the retina. The author has introduced an important variation by employing coloured instead of white light for the second stimulus, and thus, in a manner, analysing the process. A full account of the apparatus is given in the paper. It consists of a tube furnished with four lenses, to which is attached a parallel rotating shaft carrying two discs. On placing the eye to the tube a narrow band of colour appears for a moment, followed immediately by a bright patch of monochromatic light filling the rest of the field. A strip of black paper pasted on one of the lenses serves as a background for the narrow band. When the band is a spectrum, and the field red, the appearance of the spectrum is that seen in temporary red blindness. When both stimuli are of the same colour the result has always been the production of a considerable degree of momentary blindness to the second flash, whether the cycle be recurring or not. When the two flashes are of different colours, whatever colour sensations are common to both are blotted out, and the remainder combined, in the resulting sensation. If neither stimulus includes any of the components of the other there is no suppression. Thus purple does not inhibit the response to green. The author says this is difficult to explain on the assumption of an independent white sensation suggested by Bidwell, and he fails to see the necessity for this assumption. If the first stimulus is green, and the second white, then, on Young's hypothesis, the second consists of red, green, and violet. Accordingly the green, which is common to both, vanishes, and the eye perceives that mixture of red, blue, and violet, so familiar in purple pigments. The action called forth seems rather to resemble those reflex ones by which the organs of vision are protected from a sudden light, namely, winking of the eyelids and contraction of the iris. The author concludes his paper by putting forward a definite physiological hypothesis. To quote his own words: "(1) There appears to be strong evidence of the existence in the retina, between the structures in which the visual impulses originate and the beginnings of the optic nerve, of a set of structures by which the intensity of the visual impulses transmitted to the central organ is regulated. (2) These structures are sensitive to light, and when excited, block, wholly or in part, visual impulses coming from the periphery. (3) The structures are cross-connected, so that the excitation of one affects those in its neighbourhood, thus increasing the contrast between a bright object and its surroundings." (He finds no evidence of any such cross-connection between one colour sensation and another.) A. E.

28. Periodic Changes in Photographic Plates. E. Englisch. (Phys. Zeitschr. 8, pp. 1-5, Oct. 1, 1901.)—Silver bromide gelatine plates (Schleussner

and Herzka) were cut into strips, which were exposed in order to the light from progressively increasing lengths of magnesium wire. On placing the strips side by side after development, alternations of light and darkness on the plate showed that the darkening of the film did not increase steadily with the length of wire burnt, but exhibited a series of well-defined maxima and minima. The contrast between the maxima and minima became more marked when the intensity of the light was increased by placing the plates nearer the burning wire. Experiment showed that the maxima and minima were produced at an early stage of the illumination, and did not alter their position during the later stages. Thus a newly exposed plate is more sensitive than one already solarised. With plates that had first been partly fixed before being developed the maxima and minima were reversed as compared with directly developed plates. The magnesium wire weighed 0.68 grm. per metre, and the lengths burned varied from 2 to 60 cm. The plates were placed at 14 cm. and 20 cm., respectively, from the flame. A. E.

29. Sensibility of Different Kinds of Undyed Silver Bromide. **Lüppo-Cramer.** (Phys. Zeitschr. 2. pp. 718-719, Sept. 14, 1901.)—The author states that the sensibility of an undyed emulsion to the less refrangible end of the spectrum is quite independent of its sensibility to the blue. He exposed for the same time to red and yellow light an instantaneous plate and one coated with pure silver bromide, and found, on development, that the latter was strongly blackened, while the former showed hardly any reduction.

E. C. C. B.

30. Optical Rotation of Cane-Sugar in Pyridine Solutions. **G. M. Wilcox.** (Journ. Phys. Chem. 5. pp. 587-599, Nov., 1901.)—On studying the optical rotation of cane-sugar dissolved in pyridine, the author obtains the following results, the numbers given referring in all cases to the D line of the spectrum: The specific rotation at 25° varies from 86.7 for a 1 per cent. solution to 88.6 for a 6.25 per cent. solution of the sugar, the change being much greater than for aqueous solutions of the same range of concentration, and in the opposite direction. The influence of alteration of temperature is also very great, the specific rotation of a 6.25 per cent. solution varying from 88.7° at -10° to 77.0° at 105°. The effect of adding increasing quantities of a 6.25 per cent. aqueous solution of cane-sugar to a solution of similar strength in pyridine, is at first a rapid diminution of the specific rotation; the values at 25° for mixtures containing 100, 90, 80, 60, 40, 20, and 0 per cent. of the pyridine solution are 88.8°, 77.9°, 73.2°, 69.4°, 67.2°, 66.0°, and 66.6° respectively. Measurements of the change of boiling-point of pyridine when cane-sugar is dissolved in it give, for the sugar, molecular weights which increase considerably with the proportion of sugar present.

T. H. P.

31. On Rotatory Polarisation in Biaxial Crystals. **H. C. Pocklington.** (Phil. Mag. 2. pp. 361-370, Oct., 1901.)—The rotation of the plane of polarisation of transmitted light has been observed in uniaxial crystals, e.g., quartz. In the present paper theoretical reasons are given for its occurrence in biaxial crystals, and the general mathematical treatment of the subject for this purpose is given. The special case of the form of the wave surface near an axis are next discussed. It is then proved that the two waves propagated in any direction are elliptically polarised, and that the ellipses are similar, but with corresponding axes perpendicular. The author then discusses the case of a plate in convergent polarised light, and that of a pair of such plates of

opposite rotatory power (Airy's spirals). The formulæ are then extended to crystals, in which the rotation is due to the arrangement of the molecules. In these cases, the forces causing the rotation are assumed to be the same for all directions of propagation of the wave, but they produce, generally, a visible effect only when the direction of propagation nearly coincides with an axis. Certain experiments are described which were made by the author with plates of cane-sugar cut perpendicular to an axis, and 0.4 to 0.8 centimetres thick. These experiments confirm the mathematical results. S. H. B.

32. *Magnetic Rotation of Light and Thermo-dynamics.* **Rayleigh.** (Nature, 64, pp. 577-578, Oct. 10, 1901.)—In a former paper the author drew attention to a peculiarity of the magnetic rotation of the plane of polarisation arising from the circumstance that the rotation is in the same absolute direction whichever way the light may be travelling. A consequence is the possibility of an arrangement by which the usual optical law of reciprocity is violated, "A point source A would thus be visible at a point B, when a source at B is invisible at A, a state of things at first sight inconsistent with the second law of thermo-dynamics." Wien, in a recent report [see Abstract No. 1088 (1901)] considering the same combination of Nicols and magnetised dielectric, arrives at the conclusion that the inconsistency actually exists. Rayleigh points out that this conclusion is due to an oversight in the reasoning. A. E.

33. *The Spectra of Hydrogen and some of its Compounds.* **J. Trowbridge.** (Phil. Mag. 2, pp. 870-879, Oct., 1901.)—The author has concluded [see Abstract No. 59 (1901)] that the so-called line-spectrum of H is due to water vapour, and that a certain amount of the latter is essential in all electrical discharges through gases. He considers that "pure H is a perfect insulator, and that the passage of electricity depends on the dissociation of H and O, by means of which change in the distribution of energy the gases are made luminous." V. Schumann [see Abstract No. 1488 (1901)] showed that pure H at atmospheric pressure transmits ultra-violet rays as well as the most perfect vacuum attainable. Maxwell's electromagnetic theory of light demands that the space between us and the sun should be a perfect insulator, otherwise the electromagnetic waves would be completely absorbed, and the earth would remain in darkness. Dewar has proved that liquid H is an insulator. The author attributes the reduction of the luminosity of a wire when an atmosphere of CO₂ is suddenly replaced by H, not to the better heat-conductivity of the latter, but to the increased resistance owing to the occlusion of H. Palladium often increases 50 per cent. in this way. "The increased length of the spark in H is not due to increased conductivity, but to dissociation of water vapour." A number of new experiments are described, supporting the author's thesis that the vapours of water and hydrocarbons are invariably present in luminous hydrogen tubes, one of the most striking being that the copper thrown off from the positive terminal was converted into "an olive-green oxide," while that from the negative was metallic. "A steady current passes through a gas at comparatively low pressure, much in the same manner as it does through an electrolyte." A number of different gases were tried with carbon electrodes, and the phenomena were very similar. With powerful condenser-discharges, oxygen is set free from commercial aluminium and magnesium. "The brilliancy of the light of tubes filled with hydrogen diminishes as the process of dissociation of water vapour goes on, and the resistance of the tube increases. It is possible to raise such a tube to the X-ray stage from a pressure of 1-2 mm., merely by the application of a

strong, steady current, the X-rays then being due to the radiations set up by the dissociation of highly rarified water vapour." Measurements and photographs of the lines are given. The research was carried out at Harvard University. S. R.

34. *The Absorption Spectrum of Chlorine.* E. R. Laird. (Astrophys. Journ. 14. pp. 85-115, Sept., and pp. 215-216, Oct., 1901.)—The author has photographed the absorption spectrum of chlorine with a 15-ft. Rowland grating, using a column of the gas 1.37 metres long. The spectrum consists of the broad absorption band in the violet already investigated by Liveing and Dewar (Chem. News, 47-121, 1883) and a line spectrum, which, at atmospheric pressure, extends from $\lambda 4799 - \lambda 5350$, and bears no apparent relation to the emission spectrum of this gas. The effect of varying the pressure of the gas was studied, and, as regards the wave-lengths of the line spectrum, no appreciable result was observed, while the large absorption band is considerably altered in breadth, but is not resolvable into lines at any pressure. For this reason the author considers the two spectra to be quite distinct and very possibly arising from different molecular complexes. In general, as the atomic weight increases, the lines in the absorption spectra of the halogens tend to shift towards the red, and to increase in number and sharpness.

E. C. C. B.

35. *The Electric Spark and its Spectrum.* C. C. Schenck. (Astrophys. Journ. 14. pp. 116-135, Sept., 1901.)—By a study of the changes produced in the spark spectrum of cadmium by variations in the period of the condenser, due to self-induction, the author divides the lines into three groups: group A, containing the so-called arc lines; group B, containing most of the spark lines; and group C, consisting of lines which extend only a short distance from the poles, and which disappear when self-induction is introduced. The mechanism of the spark was investigated by means of a revolving mirror. Photographs of the curved streamers were obtained, which show that the latter originate at the cathode. The lines of group B are the result of these oscillations only, while those of group A are due partly to them and partly to a luminosity which commences in the centre of the spark-gap a trifle later than the first discharge, and persists some time after the oscillations cease. Under the influence of a magnetic field, also, the lines of groups A and B show quite different behaviour. E. C. C. B.

36. *Magnetic Rotatory Dispersion of Sodium Vapour in the Interior of an Absorption-Line.* O. M. Corbino. (Accad. Lincei, Atti, 10. pp. 137-138, Sept. 15, 1901.)—Experiments are described to demonstrate this effect by the inflection of horizontal fringes in the same direction on each side of a Fraunhofer line; but within the line they are on the whole not much displaced; the rotation cannot be more than 18° , which is at variance with theory, according to which it should not be less than 200° . A. D.

37. *Structure of Spectra on the Electron Theory.* W. Sutherland. (Phil. Mag. 2. pp. 245-274, Sept., 1901.)—The paper introduces various suggestions, with confirmatory reasoning, in the endeavour to trace the structure of spectra to two facts—(a) that the atoms vibrate as deformable, but practically incompressible, bodies of finite calculable rigidity, so that their surfaces have stationary waves corresponding to the fundamental mode of vibrations and its harmonics; (b) that electrons, in describing nearly circular orbits round

an atom, out of an infinity of such orbits possible, have orbits of certain frequencies made predominant by resonance. The orbits for a positive electron will be different from those of a negative one, and thus a relative motion between the two will be set up. Regarding these motions as taking place at different angular velocities in a circular path, formulæ are derived which explain Balmer's and Rydberg's formulæ, and further, Rydberg's laws lead to the conclusion that the fundamental angular velocity of all electrons associated with atoms is a constant representing a frequency of 33×10^{14} per second. The mechanical periods of vibration of the atoms are calculated from the rigidities of the metals at absolute zero, and are proved to exhibit simple harmonic relations. The spectra of different elements thus appear to be caused by practically one and the same form of electrical appliance, a pair of electrons, which is supplied with energy by the atom at various internodes. One spectrum would thus be only a slight kinematical variation of another.

C. P. B.

38. Complete Emission Function. P. G. Nutting. (Phil. Mag. 2, pp. 379-386, Oct., 1901.)—The author develops the Wien formula expressing the relation between emission, temperature, and wave-length of the radiation from a perfect radiator, by first considering separate functions for temperature and wave-period, and then combining them, with the necessary limitations suggested by experiment. The resulting functions are then extended to apply to the emission from partial radiators. [See also Abstract No. 502 (1901).]

C. P. B.

39. Emission Function of Body Emitting a Line-Spectrum. A. W. Porter. (Phil. Mag. 2, pp. 573-574, Nov., 1901.)—The author gives a single term formula to represent the radiation of hydrogen, in place of the series formula suggested by Nutting (see preceding Abstract), and, by means of the Wien radiation function, gives an expression capable of representing the whole series of spectra of an element.

C. P. B.

40. Röntgenised Air. E. Villari. (N. Cimento, 2, pp. 131-144, Aug., 1901. Rend. della R. Accad. Sci. di Bologna.)—The author employed a similar apparatus to that used in his previous experiments [see Abstract No. 1643 (1901)]. The Crookes tube was enclosed in a lead case with an aluminium window; this and the coil were enclosed in an earthed zinc case. Opposite the aluminium window was placed the aluminium window of a second lead case provided with inlet and outlet tubes, through which air was driven, and Röntgenised in its passage. The following is a summary of the experimental results:—When Röntgenised air was passed through an insulated zinc tube, and one pole of a dry pile was held near the wall of the tube at its outer end (but out of the current of air), the tube became strongly charged with electricity of the same sign as that of the pole. There was no charge unless the air were Röntgenised. As the distance between the pole and the end of the tube increased the charge diminished, and practically no charge was perceptible when the distance was 30 cm. If the tube be earthed and the air allowed to impinge on a metal ball, this becomes charged in the same way.

A screen placed between the tube outlet and the pole of the dry pile prevents the tube or ball becoming charged. This tends to show that the air reaches the pole by diffusion, and communicates its charge to the tube, but this view is contradicted by the following facts:—The air in issuing from the

tube was found to draw air with it from the pole. If the tube be surrounded by a second metallic tube, concentric with and insulated from it, and the pole of the dry pile be placed near the outer tube, the inner tube becomes charged as before, while the outer takes the opposite induced charge. The same result is obtained if the inner tube be of glass. G. H. B.

41. *Magnetic Analysis of Radium Rays.* H. Becquerel. (Comptes Rendus, 182. pp. 1286-1289, 1901.)—An improvement is described on an earlier arrangement of apparatus [see Abstract No. 1077 (1901)], and by means of screens, apertures, and sensitive plates, a homogeneous radiation can be produced and recognised. It is found that the undeviated rays, and those least deviated by a magnetic field, traverse a thin aluminium plate without absorption, and produce little or no secondary radiation. The rays deviated, and partially absorbed, pass through the aluminium without change of path, and excite intense secondary rays on each side of the aluminium. Secondary rays are shown to have a constituent which suffers deviation, and the mean curvature of secondary rays emitted by lead is in the same sense, and appears to be of the same magnitude as that of the exciting rays. G. E. A.

42. *Radio-activity induced by Kathode Rays.* J. C. McLennan. (Phys. Zeitschr. 2. pp. 704-706, Sept. 7, 1901.)—The only case of radio-activity induced by kathode rays in a neutral substance has been that of bismuth, discovered by Villari. The author finds that a very large number of salts are brought to a condition in which warming them makes them radio-active for a short time, the supply of negatively charged particles discharged from the surface then coming to an end. A. D.

43. *Influence of Becquerel Rays on Bacteria.* E. Aschkinass and W. Caspari. (Ann. d. Physik, 6. 3. pp. 570-574, Nov., 1901.)—An account of some experiments which show that Becquerel rays, like ultra-violet light, exercise a harmful influence on the development of some kinds of bacteria. R. S. W.

44. *Physiological Action of Radium Rays.* H. Becquerel and P. Curie. (Comptes Rendus, 182. pp. 1289-1291, 1901.)—Curie has repeated Giesel's two hours' experiment, exposing the arm to the action of radium for 10 hours, the active barium chloride used being relatively feeble (5,000 times that of uranium). After the action the skin was red, having the appearance of a burn, but with little or no pain. After some days the redness was intensified, but did not spread. After 20 days a crust formed, then a sore, which was dressed; after 42 days the skin began to form round the edges, but a sore 1 sq. cm. in area still remained at the end of 52 days. Becquerel carried in a waistcoat pocket a small sealed glass tube containing several decigrams of very active radiferous barium chloride (800,000 times that of uranium). The tube, wrapped in paper, was carried in a small cardboard box on two successive days, the total exposure being 6 hours. After 10 days a long oval spot appeared on the skin. This became redder, and after 20 days the skin began to peel, and the part most attacked to suppurate. The sore was dressed, and it healed in 49 days after the application of the rays, leaving a cicatrice. These and other experiments show that the time required for the effect of the rays to develop varies with their intensity, and with the time of exposure. The handling of tubes and capsules containing active products caused an action on the hands and nails, resulting in pain and peeling of the skin. G. E. A.

HEAT.

45. *Thermometry*. L. Holborn. (Ann. d. Physik, 6. 2. pp. 242-258, Oct., 1901. Communicated by the Phys. Tech. Reichsanstalt.)—The first part of this paper describes the method of comparison of certain platinum thermometers with a hydrogen standard, using liquid air for the lower temperatures, the lowest temperature attained being $-182^{\circ}7$. For platinum the mean resistance value for three thermometers is—

$$R = R_0 (1 + 0.008934t - 0.00000988t^2).$$

In the second part a similar comparison is made for nitrogen, using the same platinum thermometers and reducing the results to the hydrogen scale. At a temperature of $-190^{\circ}0$ on the hydrogen scale the nitrogen thermometer reads about $-190^{\circ}5$, in each of seven recorded observations. In comparing platinum thermometers with nitrogen thermometers at high temperatures the temperature bath used was potassic nitrate heated electrically, as described by L. Holborn and A. Day [see Abstract No. 2008 (1900)]. The results obtained are compared with those of Chappuis and Harker, and also with those of Callendar, Dickson, and Dewar. As a check upon the validity of the equation for the platinum thermometer at low temperatures, the boiling-point of liquid oxygen was observed, and was found to be $-182^{\circ}7$ C.

Various substances were examined with a view to finding one suitable for liquid expansion thermometers for temperatures as low as the boiling-point of liquid air. Petroleum ether was finally adopted, but as it can scarcely be regarded as a definite substance, the authors do not consider it to be altogether satisfactory. For their purpose they selected a commercial sample boiling at 38° C., and distilled from it at 25° – 90° the liquid for their experiments. [The dephlegmator appears to have been of rather a primitive form, so that the resulting substance is perhaps less definite than it need have been.] In conclusion, the petroleum thermometers are compared with platinum thermometers, the deviations at different temperatures on different days are tabulated, and some notes are given as to the difficulties of construction of petroleum thermometers.

R. A.

46. *Isothermals of Mixtures of Hydrochloric Acid Gas and Ethane*. N. Q. Gzn. (Zeitschr. Phys. Chem. 39. pp. 14-26, Nov. 12, 1901.)—Extensive observations were made on the behaviour of various mixtures of HCl and C_2H_6 . The corresponding values of the volume and pressure at different temperatures are given in a set of tables and are shown by curves. The main points of the theory of the behaviour of mixtures of two substances as given by van der Waals and others are confirmed by the experiments.

J. J. S.

47. *Law of Equal Partition of Energy and van der Waals' Theorem*. S. H. Burbury. (Phil. Mag. 2. pp. 408-417, Oct., 1901.)—The law asserts that for a system of molecules in stationary motion within a space bounded by elastic walls impermeable to heat, the chance of the coordinates lying between x_1 and $x_1 + dx_1$, ... &c., is proportional to $e^{-2hx} d\sigma$, where h is $4/3$ of the mean kinetic energy of each molecule, a constant; $d\sigma$ the continued product of the differentials $dx_1 dy_1 \dots dz_n$, and χ is the potential of all the forces acting on

the molecules in that configuration. Boltzmann's proof (*Vorlesungen über Gas Theorie*, part i. p. 184) assumes that the molecular velocities are independent, which leads to the expression $A e^{-\frac{1}{2}Q} d\phi d\psi$ for the chance of the molecules having their coordinates between the foregoing limits, and their velocities within the limits u_1 and $u_1 + du_1 \dots u_n$ and $w_n + dw_n$; where $d\phi$ is the continued product of the velocity differentials, and $Q = \sum m(u^2 + v^2 + w^2)$, a function of the masses and velocities only, while A is, omitting numerical factors, a function of the coordinates only. It then easily follows that $A = e^{-\frac{1}{2}\Sigma\chi}$, which the author prefers to modify into $A = e^{-\frac{1}{2}\Sigma\chi}$, where χ is now for any molecule the potential of all the forces acting on it, including intermolecular forces. The author then shows that wherever this law is applicable there must be inequalities of density. These will not be measurable, as the mean density will be constant for the smallest measurable volumes, the number of molecules in each being practically infinite. Non-linear functions of the densities, however, such as the potential, and the virial of the intermolecular forces, cannot have in the irregular system the same mean value as if the density were uniform.

The author then discards Boltzmann's fundamental assumption, and taking for Q the more general form—

$$Q = \sum m(u^2 + v^2 + w^2) + \sum \sum b_{ik}(u_i u_k + v_i v_k + w_i w_k),$$

where b_{ik} is a function of the distance r_{ik} between the two molecules to which i and k relate, he obtains a modified form of Boltzmann's law expressed by $A = e^{-\frac{1}{2}\Sigma\mu\chi}$, where μ is a function of the masses and of b_{ik} , being a constant when all the molecules are similar, and, in the limiting case of an infinitely rare medium, unity. The physical results are of the same general character as those of Boltzmann's.

The author then propounds the question, "Is not the law, whether in Boltzmann's, or in the modified form, the characteristic of gas, as distinguished from other states of matter?" This leads to the consideration of van der Waals' theory, according to which the gaseous and liquid states are continuous, and the author's conclusion is that though both Boltzmann's law and the theory of van der Waals are doubtless true, they cannot both hold good for the same substance in the same state. For a gas contained in a cylinder with an air-tight piston and slowly compressed so as to maintain the motion in the stationary condition, Clausius' equation gives $\frac{3}{2}p\omega = T + U$, where p is the pressure on the piston, ω the volume of the gas, T its kinetic energy, and U the virial of the intermolecular forces, supposed wholly attractive, so that U is negative. The density is then, in van der Waals' theory, assumed constant, and therefore proportional to $1/\omega$; also that the resultant of the intermolecular forces vanishes except close to the boundary. U there varies as $1/\omega^2$, giving the factor $p + a/\omega^2$ in van der Waals' equation

$$\left(p + \frac{a}{\omega^2}\right)(\omega - b) = rT.$$

Now if the law $e^{-\frac{1}{2}\Sigma\mu\chi}$ prevail, this uniform distribution is impossible, except perhaps in the limiting case where the density is so great that any deviation from uniformity would make χ infinite. Therefore the two laws cannot coexist. The assumption of van der Waals that the finite intermolecular forces are wholly attractive would tend to increase the want of uniformity—in fact, if Boltzmann's law applied, the perfectly uniform distribution assumed

by van der Waals would then be the most improbable of all possible ones. The former law is true for gases: if the latter is also true for gases there must be a sharp dividing line on one side of which Boltzmann's law holds, and on the other that of van der Waals. Boltzmann's analysis does not admit of any such abrupt change, which, however, would occur, with certain volume and temperature conditions, under the author's modified form of the law, through the changing of sign of Q . This cannot, however, be considered as removing the difficulty inherent both in Boltzmann's law and its modification by the author. The modification merely suggests possible means of escape. The author points out that molecular streams must necessarily result from the variations in density, and therefore molecules of unequal masses cannot have equal mean energies of translation. His former conclusion [see Abstract No. 506 (1901)], that the energy which is equally partitioned is not the whole energy of translation, but only a certain definite portion of it, is therefore confirmed.

Against Boltzmann's proof of the law of equal partition (Vorlesungen, part ii.), which agrees in substance with those of Maxwell and Rayleigh, he makes the following objection. Expressing the kinetic energy of a system in the form

$$E = a_1 r_1^2 + a_2 r_2^2 \dots + a_n r_n^2,$$

where $r_1, r_2, \dots$ are Boltzmann's "*momentoids*," the latter's proof implicitly assumes that all combinations of the r 's which satisfy this are equally probable, which is no more self-evident than the proposition which it is employed to prove. What is really proved is, not that every ar^2 is in fact equal to every other, but that, in the present state of our knowledge, we have no reason for saying that any of them, or if any which, is greater than any other.

G. W. DE T.

SOUND.

48. Acoustical Notes. Rayleigh. (Phil. Mag. 2. pp. 280-285, Sept., 1901.)

—*Forced Vibrations.*—If free vibrations be represented by $\cos nt$, and if the forced vibration due to a force acting with a very long period be $\cos pt$, then the actual forced vibration will be $n^2/n^2 - p^2 \cos pt$. From this it follows that (1) in all cases the forced vibration takes its period from the force, whatever may be the natural period; (2) for $p < n$, the phase is the same as if the vibration were infinitely slow (the vibrator would be at any instant of time in the position where the momentary force would permanently maintain it); (3) for $n < p$ the phase of the actual vibration is opposite to that defined in (2); (4) if the force have very nearly the period of the free vibrations the effect is much enhanced, even reaching infinity; hence viscous forces must be brought into the reckoning. The author then describes lecture experiments with Thomson galvanometer mirrors to demonstrate these four cases. *Vibrations of Strings.*—The difference in Melde's experiment (tuning-fork, string, pulley, and adjusted weights) between the forced vibrations when the fork works athwart the string, and the vibrations of half the frequency when the fork acts along the length of the string, is demonstrated by illuminating the string by sparks synchronous with the fork: in the former case the string is seen single, in the latter it is seen double. *Beats of sounds led to the two ears separately.*—The results do not exclude the view that the comparatively feeble beats heard may be due to the passage of sound from one ear to the other through the bones of the head, or perhaps through the Eustachian tube. *Loudness of double sounds.*—Beats sound louder than either of the component sounds; according to theory the intensity, which is proportional to the energy propagated, should be, at the loudest, four times as great as either of the components. Two sounds differing by a minor third did not seem louder than either of the components. A. D.

49. Period of a Rod Vibrating in a Liquid. M. I. Northway and A. S. Mackenzie. (Phys. Rev. 13. pp. 145-164, Sept., 1901.)—Historical résumé, and discussion. In water the lowering is, within a range of $8\frac{1}{2}$ octaves, independent of the pitch; the lowering for a rod of given cross-section is independent of the length, is approximately the same for brass and steel, and is probably independent of the material, within the range of substances ordinarily used; for a rod of given width it is approximately inversely proportional to the thickness; and for a rod of given thickness it is approximately directly proportional to the width. The effect of viscosity of the liquid is not very marked; but the lowering increases with increased density, the increase not being far from being directly proportional to the added density as compared with water. The authors discuss various formulæ for the lowering-ratio T/T . A. D.

ELECTRICITY AND MAGNETISM.

THEORY AND ELECTROSTATICS.

50. *Integration of the Equations of Propagation of Electric Waves.* A. E. H. Love. (Roy. Soc., Proc. 68, pp. 19-21, March 5, 1901 (Abstract) and Roy. Soc., Phil. Trans. 197, pp. 1-45, July 17, 1901.)—Huygens' principle, which until recently formed the basis for the investigation of wave propagation in the Undulatory Theory of Light, is indefinite, inasmuch as the nature and intensity of the sources of secondary waves are unrestricted, save by the conditions [first postulated by Fresnel] that the secondary waves must combine in advance so as to give rise to the disturbance actually propagated, and must interfere in rear so as to give rise to no disturbance. These conditions are insufficient, and the propagation of light waves is now investigated [this was first done by Kirchhoff] from the system of partial differential equations which they satisfy. This system has the same form both in the theory of an elastic solid ether, emitting transverse waves, and in the electromagnetic theory; the components of the vector quantities involved satisfying, in either case, a partial differential equation of the form $\nabla^2 \phi / \partial t^2 = C^2 \Delta^2 \phi$, where C is the velocity of radiation. This equation occurs in the Theory of Sound, and was integrated by Poisson in 1820, but a much more general integral, including that of Poisson as a special case, was obtained by Kirchhoff in 1888, as a solution of the problem of the propagation of luminous waves. The function ϕ , satisfying the equation of propagation, was assumed to have the properties; (1) that outside a given closed surface, S , ϕ , and its first and second differential coefficients with respect to x, y, z , are everywhere finite and continuous; (2) that ϕ vanishes at infinite distances from S . Green's theorem was then applied to ϕ , and to an auxiliary function V which satisfies the equation of propagation at all points except a single point O outside S , and has the form $F(r + Ct)/r$, where F is a function to which suitable properties are assigned.

The vector quantities involved in the equation of propagation are two in number, and, considering the waves as electric disturbances, may be taken to be the electric and the magnetic force respectively. Every one of the vectors in question is circuital, this being the criterion of transversality of a vector disturbance propagated by wave motion. The circuital condition excludes some of the known particular solutions of the equation, but the author obtains a very general system of available particular solutions, from the synthesis of which more general solutions can be obtained. These particular solutions are expressed in terms of spherical harmonics and arbitrary functions of the time. The expression in spherical harmonics is immediately suggested by considering the form of Kirchhoff's function V as corresponding to the solution r^{-1} of the equation $\nabla^2 \phi = 0$, and the solutions may be considered as generalisations of those obtained by Lamb in his treatise on Hydrodynamics, from which they differ only in containing arbitrary functions of the time in place of simple harmonic functions. By means of these solutions, two types of sources of electric radiation can be described, the sources of one type being similar to infinitesimal Hertzian vibrators, being related in the same way to an axis, the dependence on time, however, of the emitted radiation being arbitrary. The sources of the second type are

obtained from these by interchanging the rôles of the electric and magnetic forces.

The author then proceeds to obtain a more general solution by a method analogous to that employed by Green for the Theory of Potential, the object sought being to express the values of the vectors at a given place and time in terms of their values at other places and times. The first step is the determination of particular solutions which tend to become infinite, in definite ways, in the neighbourhood of chosen points. These are found among the solutions previously obtained. A reciprocal theorem, analogous, in this theory, to that of Green in the Theory of Potential, is then obtained, by a modification of the process by which the equation of propagation is to be obtained from the Action principle, and enables a relation to be established between the values, on any selected surfaces, of two sets of solutions. A modification of Kirchhoff's analysis is then employed to determine the limiting form assumed by this theorem, when the solutions of one system have the assigned character of infinity at a given point. The result arrived at in this manner is that the radiation arriving at a given point may be regarded as due to the distribution of imagined sources of radiation, of the two types previously specified, and having the directions of their axes, and the intensities of the radiation they emit, determined entirely by the values, on the surface, of the vectors involved in the propagation of the waves, upon an arbitrary closed surface, separating the point from all the actual sources of radiation. The general theorem is then applied to the problem of the passage of radiation through an aperture, and, the general problem presenting too great difficulties, it is simplified by the assumptions: (1) that the incident radiation is represented by simple harmonic functions of the time; (2) that the surface is plane. (1) eliminates vector potentials; and (2) is a practically unimportant restriction when the aperture is small. It is then shown that when a train of radiation comes to a perforated screen, or when electric vibrations take place in the dielectric on one side (the nearer side) of a conducting surface, in which there is an aperture, waves are sent out into the medium on the farther side; but the aperture also has the effect of generating a system of standing waves on the nearer side. These systems of waves become, to a great extent, determinate, if we combine with the general theorem the conditions of continuity of the dielectric on the two sides of the aperture. The determination is practically complete when the medium on the nearer side is the dielectric plate of a condenser in which electric vibrations are taking place; and the result can be applied to determine the rate of decay of the vibrations due to transference of the energy to the external dielectric. The example of a condenser with concentric spherical conducting surfaces, the outer conducting sheet being perforated by a small circular aperture, is worked out in detail; and the results suggest that the maintenance of the vibrations depends on the screening action of the outer conductor rather than on the largeness of the capacity of the condenser; in fact, the vibrations of the spherical condenser are much more slowly damped when the capacity of the condenser is small than when it is large, the outer conductor and the aperture remaining the same.

G. W. DE T.

51. *Symbolic Integrals of Electromagnetic Equations derived from Initial Conditions.* L. Silberstein. (Ann. d. Physik, 6. 2. pp. 878-897, Oct., 1901.)—If ϕ be any operator on x , and $\phi(x)$ denote the result of performing that operation n times in succession, then $f(\phi)$ is an operator having a definite meaning, if at least $f(\phi)$ be expressible in positive integral powers of ϕ , $\cos \phi(x)$, for

instance. In the electromagnetic field we have the two vectors, E , electric force, and M , magnetic force, which satisfy the relations—

$$\frac{dE}{dt} = \frac{1}{AK} \text{curl } M, \text{ and } \frac{dM}{dt} = -\frac{1}{A\mu} \text{curl } E.$$

The conjugate relation here indicated is important.

From these equations, if E_0 and M_0 be given at any point in the field when $t=0$, then, by successive differentiations and eliminations, E_t can be found in the form—

$$E_t = \{ \cos(vt \text{ curl}) \} E_0 + \left(\frac{\mu}{K} \right)^{\frac{1}{2}} \{ \sin(vt \text{ curl}) \} M_0 \dots \dots \dots (A)$$

and M_t in the corresponding manner. Here $\frac{1}{v^2} = A^2 \mu K$.

It is shown that these equations, $\cos(vt \text{ curl})$ and $\sin(vt \text{ curl})$, satisfy the ordinary trigonometrical relations.

Our author next deals with the following difficulty. If E_0 and M_0 are both zero throughout any defined space, then by the above equations they must remain zero for all time throughout that space. And therefore no electromagnetic disturbance can ever travel into it. The proposed solution of the difficulty is that there may be surfaces of discontinuity at which the space differential coefficients, and therefore also the time differential coefficients, of E or M become infinite. Hence the process fails by the failure of Taylor's theorem. He next treats of certain special cases, as for instance that in which E and M are resultants of harmonic vibration.

If D stand for $\frac{d}{dt}$, we have from the fundamental formulæ $\frac{1}{v^2} D^2 E = -\text{curl}^2 E$ or $v^2 \text{curl}^2 = -D^2$, whence, introducing $i = \sqrt{-1}$, $iD = \pm v \text{curl}$, so that D can by this substitution be applied to the initial values E_0 and M_0 , otherwise $\frac{dE_0}{dt}$ would have no meaning. When used in this sense, D is written D_s . By substitution in equation (A)—

$$E_t = \{ \cos(i t D_s) \} E_0 \pm \sqrt{\frac{\mu}{K}} \{ \sin(i t D_s) \} M_0,$$

with a corresponding expression for M_t from which it is shown to follow that—

$$E_t = \{ \cos(i t D_s) \} E_0 + i \{ \sin(i t D_s) \} E_0;$$

$$M_t = \{ \cos(i t D_s) \} M_0 + i \{ \sin(i t D_s) \} M_0.$$

The application of the formula $e^{i\phi} = \cos \phi + i \sin \phi$ is now evident. If H_t be an operator which converts ψ_0 into ψ_t , H_t satisfies the condition $H_{tt} = (H_t)^2$, whence we are led to $H_t = e^{it}$, where F is now an operator independent of t . In the same way if K_R be an operator which converts ψ_R into ψ_Q , P and Q being two points in space, and R the vector PQ , it is shown that $K_{RR} = (K_R)^n$, n being any integer. And this leads to the general form $\psi_{xyx} = e^{\frac{x}{a} \frac{d}{dx} + \frac{y}{b} \frac{d}{dy} + \frac{z}{c} \frac{d}{dz}} \psi_{x=0, y=0, z=0}$. The theory is then extended to the case of imperfect conductors by development of the formula—

$$\mu A^2 \{ RD^2 + \lambda D \} E = -\text{curl}^2 E$$

where λ is the conductivity.

S. H. B.

52. *Interpretation of Maxwell's Electromagnetic Equations in Isotropic Media at Rest.* J. Sauter. (Ann. d. Physik, 6. 2. pp. 331-338, Oct., 1901.)—The writer assumes a substance, having inertia, and extending continuously through infinite space, and at a given time subject to certain strains. Considering a closed surface S , and a point O on its surface, dS being an element of surface at O , and n_a the direction of the normal measured outwards, the existing stress consists in a force PdS acting on dS , and equal to $V. E N_a$ where E is a force varying with O and with the time, but independent of n_a , and N_a is a unit vector in the direction n_a . Hence are derived the principal equations of motion. It is assumed (a) that the density at every point is independent of the time; (b) that the sudden removal of the constraint at any time would leave the motion uninterrupted without change of the distribution of the velocities in space; (c) that initially when $t = -\infty$ the velocity was everywhere zero. From the consideration of this medium the writer passes to that of a medium consisting of discrete particles, each having its centre fixed in space, but capable of turning about an axis through the centre, the orientation of which varies. He obtains a system of equations of the same form as Maxwell's, as generalised by Boltzmann. In this system μ , the density of the author's medium, corresponds to Maxwell's magnetic permeability, the vector E , to the internal electric force, B (or μH) to the magnetic induction, H to the magnetic force. Also D , which, in the author's mechanical theory, is the inclination of the axis of a particle to its position of equilibrium, corresponds to Maxwell's electric displacement. S. H. B.

53. *Poynting's Theorem.* W. S. Franklin. (Phys. Rev. 13. pp. 165-181, Sept., 1901.)—A series of papers by P. S. Wedell-Wedellsborg [see Abstracts Nos. 186 (1898), 96 and 1831 (1900)] criticising Maxwell's equations in general, and Poynting's theorem in particular, suggested the supplementing of Poynting's original discussion in some particulars. Poynting's theorem is a necessary consequence of Maxwell's equations, and therefore must hold good if they are true, and the author considers that an understanding of the theorem and the conviction of its truth can only be obtained through these equations. The theorem asserts that the energy stream is, at any point, perpendicular both to the electric and magnetic fields, and that the amount of energy which in one second streams across an area of 1 sq. cm. at right angles to the stream is equal to $1/8\pi \cdot EH$, where E is the electric field intensity, and H is that of the magnetic field. J. J. Thomson has pointed out (Recent Researches, p. 313) that, although Poynting's expression for the energy stream is perhaps the simplest expression that will satisfy the conditions, it is not the only one, since any energy flow which has no convergence may be superposed upon the Poynting stream without changing the distribution of energy.

Much of the criticism has been directed against Poynting's examples. Now an example of the theorem is necessarily a solution of Maxwell's equations for a particular case. This requires a complete knowledge of the boundary conditions and of all singularities within the region, which makes a solution for any ordinary current generator and its circuit quite impracticable. Wedellsborg's earlier criticisms were satisfactorily met by D. A. Goldhammer (Zeitschr. Phys. Chem. 23. p. 686, 1897), and these, and also his later ones, by Scheye [see Abstracts Nos. 1287 (1898) and 848 (1900)]. G. Mie [see Abstract No. 2438 (1900)] has well met the need of a numerical solution of Maxwell's equations for a particular case involving the flow of energy into a conductor. In Scheye's last-mentioned paper he agrees with Wedellsborg's contention that the electric field distributions required by Maxwell's equations do not agree

with experiment, in so far as to admit that further decisive experiments are required. The author does not agree with this admission. The electric field intensity at a point where the current density is i , of a homogeneous conductor of specific resistance r , is ri . Therefore, if the current is steady, r being constant, ri can have no convergence, and there is therefore no free charge in the interior; also, near the boundary of the conductor, i , and therefore also the electric field, is parallel to the surface. The field distribution outside depends on conditions that, at each point of the surface of the current conductor, the tangential component of the external field should be equal, both in magnitude and direction, to the value of ri inside the surface; and that at each point of the surfaces of other conductors in the region the tangential component must vanish. The electric lines of force are therefore never quite normal to the surface of a conductor carrying current, but may in special cases be parallel to it.

With regard to the experimental evidence, Ohm's law shows that the potential gradient parallel to a wire is equal to ri , and this law is verified by a great mass of experimental evidence. On the other hand, the so-called capacity effects on long transmission lines and in submarine cables are due immediately to the component of the electric field at right angles to the surface of the conductors; all practical calculations of these capacity effects are based directly or indirectly on Maxwell's equations, and these calculations agree with experiments as closely as could be expected, considering that the calculations are mostly only approximations, and are usually based upon hypothetically simplified data for the dielectrics and magnetic substances experimented with. The author considers that the submarine cable tests by Crehore and Squier [see Abstract No. 1969 (1900)] constitute the most complete experimental verification hitherto published of the theory of the electric circuit involving both electric and magnetic energy. He calls attention to the fact that for short circuits the electrical energy is negligible in comparison with the magnetic energy, while for extended ones, such as long transmission lines, the former may even exceed the latter in amount. The paper concludes with some instructive and interesting particular solutions of Maxwell's equations, illustrative of Poynting's theorem, selected for their simplicity and for their capacity of representation in two dimensions, so that the accompanying diagrams represent the solutions completely.

G. W. DE T.

54. *Rowland's Experiment.* A. Eichenwald. (Phys. Zeitschr. 2. pp. 708-704, Sept. 7, 1901.)—In view of Crémieu's earlier work, the author has repeated Rowland's experiment on the magnetic effect of convection of electric charges, and has obtained results which quantitatively confirm Rowland's.

A. D.

55. *Electric Field Produced by Magnetic Variations.* V. Crémieu. (Annal. Chim. Phys. 24. pp. 85-118, Sept., 1901.)—After an historical introduction the author shows that a change rate $d\phi/dt$ in the magnetic flux should give rise to a ponderomotive force $f = m/2\pi r \cdot d\phi/dt$. Experiments undertaken to confirm this are described, with the precautions observed, but the results were entirely negative.

A. D.

56. *Magnetic Effect of Electric Convection.* V. Crémieu. (Annal. Chim. Phys. 24. pp. 145-204, Oct., 1901.)—The paper contains a description and critical discussion of the experiments of Rowland (Amer. J. Sci. xv. p. 80, 1878; positive results), Lecher (negative), Himstedt (positive), Rowland and

Hutchinson (Phil. Maga. xxvii. 445, 1899; positive results). In all these researches the measuring apparatus was placed in a region which was the seat of perturbations of all sorts; the deviations obtained were too feeble, and were of the same order as those due to these perturbations; and the precautions taken to ensure that the charge of the disc was really carried round were insufficient. The author devised apparatus to get over these difficulties, brusquely creating a convection current and observing its effect upon a neighbouring induction circuit, with a control by an adjusted circuit-current of calculated strength. The practical difficulties met with are described, and their solution. The results arrived at are that where, for example, the deviation of the light spot should have been at least 37 mm. in a given direction, the maximum deviation obtained was 7 mm. on one side or the other of the zero, apparently accidentally; while the control-current of calculated strength gave, with the apparatus in use, exactly the calculated deviation, always in the proper direction. Further experiments are described, which were made in view of discussions with Pellat, Carvallo, Poincaré, and Blondlot, but the author still obtains only negative results. A. D.

57. *Particulars of Damage Caused by Lightning.* **F. Neesen.** (Elektrotechn. Zeitschr. 22. pp. 991-998, Nov. 28, 1901.)—In this paper there are given particulars of the damage done to three sheds in the gunpowder works at Wahn, and also of the lightning conductors thereon; similar particulars are also given relating to the overhead system of the Berlin Street Railway. C. K. F.

DISCHARGE AND OSCILLATIONS.

58. *Emanations of Phosphorus.* **C. Barus.** (Phil. Mag. 2. pp. 391-408, Oct., 1901.)—The third of a series of papers [see Abstract Nos. 1669 and 2204 (1901)]. The present experiments relate to the apparent decay, with lapse of time, of the ionisation produced by phosphorus emanation between the plates of a condenser, for fixed distances between the condenser-plates, and to the transmission of the ionisation through layers of air and other media. The author concludes that it is improbable that the rate of production of ions by the phosphorus diminishes with lapse of time, and that the decrease of conductivity is more probably due to fluctuations of temperature and similar incidental causes. The author next proceeds to find mathematically the change in the number of ions per cubic centimetre with change of the distance between the condenser-plates. Experiments made to ascertain whether the ionised particles exhaled by phosphorus are accompanied by some form of obscure radiation gave results against the existence of such radiation. The emanation is stopped by non-porous media, however thin. Other experiments described show the effect of sulphuric acid and of ammonia polysulphide, when used in place of phosphorus as "dust" producers. W. C. H.

59. *Simultaneous Volumetric and Electric Graduation of Steam-tube with Phosphorus Ioniser.* **C. Barus.** (Phil. Mag. 2. pp. 477-488, Nov., 1901.)—A continuation of the author's investigations on ionised phosphorus emanation. The current of air passes through a tubular condenser before entering the colour tube, and the current in the condenser is measured simultaneously with observation of the volume of air passing. As no change takes place in the colour-tube when the condenser is charged or discharged, it is evident

that only an insignificant number of the nuclei present take part in the radial convection of electricity across the condenser; but, on the other hand, the current varies with the number of nuclei present. Tables of results and curves are given, and the author enters into a mathematical discussion of his results. [See further Abstract No. 2204 (1901).] W. C. H.

60. Effect of Temperature and of Moisture on Emanation of Phosphorus, and Distinction in Behaviour of Nuclei and of Ions. C. Barus. (Amer. Journ. Sci., 12. pp. 827-846, Nov., 1901.)—These experiments form a continuation of the author's earlier work on phosphorus emanation [see Abstracts Nos. 1809 and 1689 (1901)]. They show that nuclei adapted to condense atmospheric moisture are produced most abundantly at about 18° C. Below this temperature the condensational activity falls off very rapidly, while above 18° it decreases slowly with rise of temperature, having lost only 25 per cent. of its value at 35°. On the other hand, the ionisation of air passing over phosphorus increases with temperature to a maximum at about 20°, declining thereafter slowly. These results may be accounted for if ionisation is a result of dissociation of nuclei, so that up to a certain point ionisation would increase as condensational activity decreases.

If the phosphorus is not quite dry to begin with, permanent electrical conduction is produced in the condenser, which does not appear when the phosphorus has been thoroughly dried in a dessicator. As the electrical conduction produced is quite out of proportion to the amount of moisture present in the phosphorus, the author thinks it probable that the emanation escapes in some combination with the moisture. If freshly cut fuming phosphorus be used in the ioniser, the currents in the condenser may be raised to nearly twice their usual value. Thus the low concentrations formerly found by the author for the tubular condensers (2×10^4 nuclei per c.c.) have been made more nearly to approach the value found from plate and spherical condensers (4×10^4). W. C. H.

61. Analogies in Electric Flow in Gases and Nernst Filaments. W. Kaufmann. (Gessell. Wiss. Göttingen, Nachr. Math.-Phys. Klasse, 1. pp. 62-73, 1901.)—The author shows, from observations of the e.m.f. and current strength in a rod of the Nernst earth placed in an electrically heated oven, that all the phenomena characteristic of discharge through gases are exhibited in discharge through the Nernst earth. Determinations were made at temperatures of 848°·5 C., 866°·5 C., and 897°·5 C. Intermittent discharge was obtained at a temperature of 808°-818° C.; the discharge period (which varied from 20 to 50 seconds) was somewhat irregular, on account of a retardation of the same character as that observed in the case of discharge through gases. The phenomena are due, according to the author, to rapid diminution of resistance with increase of temperature. D. H. J.

62. Effect of Inserted Bodies in an Electric Discharge. M. Toepler. (Ann. d. Physik, 6. 2. pp. 339-346, Oct., 1901.)—Using one of his own influence-machines of several plates, the author tries the effect of—(1) glass plates pierced with small holes; (2) small metal bodies in the line of discharge between the poles. The colour effects in the several cases of glow, brushes, and sparks are set forth. The conclusion reached is that, when the discharge is increasing, a row of more or less well-coloured patches of light is always to be seen in it. P. E. S.

63. *Electric Discharges from Points.* **F. Tamm.** (Ann. d. Physik, 6. 2. pp. 259-279, Oct., 1901.)—Experiments were made to test the effect of different air pressures on the rate of discharge of static electricity from points. The result is found capable of representation by a formula. The effect of moisture of the air is also dealt with, and the results tabulated.

E. H. B.

64. *Inconstancy of Spark Potential.* **K. R. Johnson.** (Ann. d. Physik, 5. 1. pp. 121-185, 1901.)—The spark discharge is discussed in several of its bearings. Referring to the Wollaston experiment cited in a previous paper [see Abstract No. 631 (1901)], the production of an H and O mixture, Knall gas, at the electrodes of a water cell placed in the secondary circuit of an induction coil, is a result of the oscillations which are set up at break. The presence of these oscillations has also been demonstrated by the Braun tube. When the Wollaston cell is placed in the secondary of a Tesla transformer, the production of the gas is accompanied by faint sparks, the gas evolution and the sparks gradually disappearing as the water is acidified. The effect of the acid is to increase the liquid's conductivity, and thereby to reduce the momentary potential gradient. When the rise of potential at either electrode becomes great enough, the electrode becomes coated with a layer of gas, which stops the electric flow, and the p.d. between electrode and electrolyte becomes great enough to cause a spark. A Hertz resonator failed to produce the gas mixture. This is put down to the high frequency of the oscillations employed combined with the lagging of the electrolyte potential behind that of the electrode. To amplify the explanation of discharge conditions, the gas in the spark-gap is compared to a wall on which an enclosed gas exerts a pressure, the wall collapsing when the pressure reaches a certain value. The electric pressure required to break down the dielectric is, by following out the analogy, proportional to the number of collisions on the wall, i.e., to the frequency of the oscillations, the reduction of the *vis viva* of the molecules corresponding to the damping of the oscillations. An ideal case is considered where the electrodes are connected by a metal in which a periodic current i is flowing such that, $i = i_0 \sin \beta t$, and the potential $V = E_1 - E_0 \cos(\beta t - \phi)$, there being no damping. Taking the *vis viva* of each collision as $(Vi)_{\max}$ and the electric pressure as $\frac{\beta}{2\pi} (Vi)_{\max}$, where $\frac{\beta}{2\pi}$ is the frequency of the oscillations, the specific strength of the gap is denoted by b , so that for a spark-gap of length λ , $b\lambda = \frac{\beta}{2\pi} (Vi)_{\max}$.

In the first case considered, where E_0 is supposed very small compared with E , and κ is written for $1/b$, the expression is reduced to—

$$\lambda = \frac{\kappa \beta i_0}{2\pi} (E - E_0 \sin \phi).$$

In the second case $E = 0$, and the expression for the length of gap becomes—

$$\lambda = \frac{\kappa \beta i_0 E_0}{2}$$

approximately. When a spark is passed across a gap in parallel with a condenser of large capacity a considerable p.d. is required. After discharge, the change in the potentials of the knobs gives rise to somewhat powerful oscillations. This is Helmholtz's "good spark." If the radius of the spark knob, at first large, is reduced, its capacity sinks also, and the frequency of the vibrations increases. It follows from the first expression for λ that the

p.d. necessary for a discharge diminishes, so that, after a certain point, the sparks pass across almost continuously, being unbroken to the eye, and a silent discharge is thus obtained. Finally, some irregularities, *e.g.*, those caused by blowing the spark, are considered. G. E. A.

65. *Photoelectric Effect near Sparking Potential.* H. Kreusler. (Ann. d. Physik, 6. 2. pp. 898-411, Oct., 1901.)—Hertz's observation that ultra-violet light affects spark discharges, through a shortening of the procrastination period (Warburg), in a manner independent of the material (iron being by exception specially sensitive), stands in a certain sense in opposition to Hallwachs' effect, the dispersion of negative charges under ultra-violet light in a manner which depends very much upon the material, iron being in this case specially insensitive. The more anodic the metal, the more readily, as a rule, is Hallwachs' effect produced: Rb has a maximum effect in the yellow, K in the blue; heavy metals require ultra-violet light. If both these effects are due to the same cause, it might be that metals of low sensitivity at low potentials were sensitive at high potentials; and this is found to be the case, the differences in the Hallwachs effect under conditions approximating to those of Hertz's phenomenon being very small as between different metals. A. D.

66. *Photoelectric Currents Applied to Ultra-violet Photometry.* H. Kreusler. (Ann. d. Physik, 6. 2. pp. 412-428, Oct., 1901.)—The great intensity of the photoelectric effect [see preceding Abstract] near the sparking potential points out an extremely delicate test for ultra-violet rays; and a method is described of applying this to quantitative work. A. D.

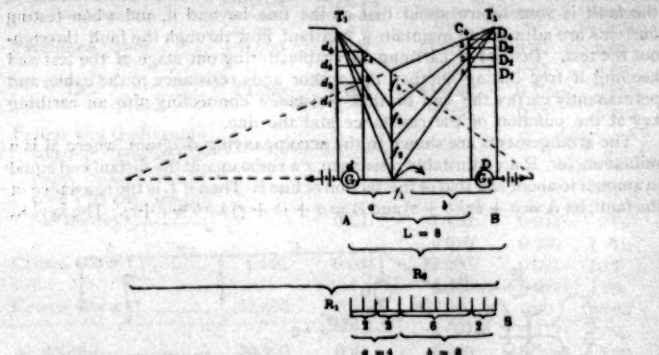
67. *Electric Overtones.* Lamotte. (Journ. de Physique, 10. pp. 589-597, Oct., 1901. Also Annal. Chim. Phys. 24. pp. 205-287, Oct., 1901.)—After reviewing the work of others, and the arguments for and against the existence of electric oscillations of higher orders along wires, the author describes his own experiments in the same direction. His final conclusions from these are as follows:—In studying electric waves propagated along wires proceeding from one of the ordinary oscillators, such as the Lecher, Blondlot, or Blondlot-Drude, one observes waves of different periods, their number being greater as the system is made longer. Among these waves one can distinguish two groups—those whose periods are comparable to the period proper to the primary, and those whose periods are comparable to that proper to the secondary. In each of the groups the lengths of the waves form a set which tends more and more towards a harmonic series as the length of the vibrating system increases. By suitably arranging the experimental conditions the harmonic series may be complete or contain the odd terms only. The observed results render it probable that in a Hertzian oscillator multiple vibrations are present forming a quasi-harmonic series. The theory of Bjerknes would then apply separately to such a couple, formed by one of these vibrations and that vibration of the resonator of comparable period. This view is, however, only hypothetical and needs confirmation. E. H. B.

68. *Influence of Electrical Waves on Chemical Action.* F. Lengfeld and J. H. Ransom. (Journ. Phys. Chem. 5. p. 502, Oct., 1901.)—Exposure for forty-eight hours to electrical waves 300 metres long did not lead to any reaction occurring between hydrogen and chlorine, or hydrogen and oxygen. W. E. T.

ELECTRICAL PROPERTIES AND INSTRUMENTS.

60. *Graphic Proof of the Betts Test.* E. Raymond-Barker. (Elect. Rev. 49. pp. 420-422, Sept. 13, 1901.)—Betts' test was treated of in Abstract No. 1684 (1901). Similarity to that of Wilbrant referred to by the writer in the Elect. Rev. of Nov. 21, 1890, is pointed out. His graphic demonstration is as follows :—

Deflections d and D on G_1 and G_2 , at stations A and B, are respectively inversely proportional to the resistances a and b , also to the *apparent* resist-



ances R_1 and R_2 due to the mutual opposition of the currents from the two cable ends at which the p.d.'s are respectively the perpendiculars T_1 and T_2 .

The accompanying figure shows a simple case where the resistance of each of the galvanometers G_1 and G_2 , at stations A and B, is equal to that of one-quarter the length of a cable conductor bisected by the fault in the relative proportion of 1 to 3. Four different conditions at the fault are shown, viz. :—

f_1 Fault making dead earth.

f_2 " with resistance to earth giving potential $f_1 f_2$.

f_3 " " " " " $f_1 f_3$

f_4 " " " " " $f_1 f_4$

The following table summarises the accompanying conditions :—

Ex.	P.D. at fault.	Right angle triangle representing deflection		Inverse proportions relative to deflections and actual resistances, i.e., deflections inversely proportional to resistances.
		on G_1	on G_2	
1	nil	$T_1 d_1 c_1$	$T_2 D_1 C_1$	$b : a :: T_1 d_1 : T_2 D_1 = 2 : 1$
2	$f_1 f_2$	$T_1 d_2 c_2$	$T_2 D_2 C_2$	$b : a :: T_1 d_2 : T_2 D_2 = 2 : 1$
3	$f_1 f_3$	$T_1 d_3 c_3$	$T_2 D_3 C_3$	$b : a :: T_1 d_3 : T_2 D_3 = 2 : 1$
4	$f_1 f_4$	$T_1 d_4 c_4$	$T_2 D_4 C_4$	$b : a :: T_1 d_4 : T_2 D_4 = 2 : 1$

The *apparent* resistances when the p.d. at the fault is $f_1 f_4$ are shown in the diagram, viz., R_1 and R_2 , and here again the inverse proportion obtains, viz. :—

$$R_2 : R_1 :: T_1 d_4 : T_2 D_4 :: 2 : 1.$$

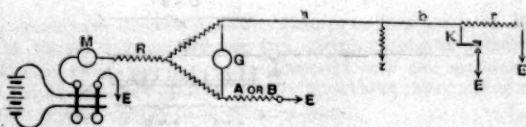
The *apparent* resistances accompanying the other three conditions are not indicated, but they may readily be obtained by continuing to the common resistance base the lines $T_1 - f_3, f_2, f_1$, and $T_2 - f_3, f_2, f_1$.

The author suggests the tests being taken when earth currents are *nil* or nearly so, which normally occurs in Atlantic cables four times in the twenty-four hours.

E. O. W.

70. Modified Blavier Test. W. J. Murphy. (Electrician, 47, pp. 958-954, Oct. 11, 1901.)—The Blavier test is only reliable when the resistance of the fault is somewhere about that of the line beyond it, and when testing currents are adjusted to maintain a constant flow through the fault throughout the test. Instead of earthing the cable during one stage of the test and keeping it free during another, the author adds resistance to the cable, and permanently earths the end of that resistance, connecting also an earthing key at the junction of the resistance and the line.

The arrangements are shown in the accompanying diagram, where M is a milliammeter, R an adjustable resistance, r a resistance at the distant end equal in amount to about half that of the section of line b . Then if L is the resistance of the fault, let $A = a + bz/(b + z)$ and $B = a + (b + r)L/(b + r + z)$. The key, K ,



is to be depressed and raised every alternate minute for, say, ten minutes. With K down, adjust the testing current to as high a value as the fault will stand without showing unsteadiness. Observe the earth current *after* the testing current has been on, and balance to it to obtain A . With K raised reduce the testing current to 0.75 of its previous value if z is anything like the value of b , or to 0.5 of its previous value if z is very high (over twenty times b), and after applying the battery for a few seconds observe the current to earth, and again obtain a balance for B . Having verified A and B by second readings, adjust the currents more closely for the remaining observations, making $C_B = C_A \frac{A - a}{B - a}$, for constant potential at the fault. Use zinc to line only. The receiving instrument may be kept in circuit either as r or as a part of r .

E. O. W.

71. Conductivity under varied E.M.F. J. C. Bose. (Electrician, 47, pp. 880-882, Sept. 20, and pp. 877-881, Sept. 27, 1901. Paper read before the British Association.)—Both simple and complex contacts were used. The conductivity of a contact is found to increase with increasing e.m.f. These changes are shown in a series of curves under varying conditions of contact and e.m.f. Cases are shown of the increase in conductivity, followed by recovery, when flashes of radiation fall on the contact.

P. E. S.

72. Dielectrics. M. v. Hoor. (Elektrotechn. Zeitschr. 22, pp. 716-719, Sept. 5; 749-751, Sept. 12; and pp. 781-785, Sept. 19, 1901. Extract from a paper read before the Hungarian Academy of Science, May 20, 1901. [See also Abstract No. 1118 (1901).])—The second article contains the results of experi-

ments made to find the variation of the dielectric constant with the slope of potential for paper, paraffin, guttapercha, glass, and micanite. The author prepared a large number of paper condensers impregnated with various paraffins, and found that very slight differences in the mode of construction and in the materials used quite altered their dielectric properties. The results are summarised in the following table, in which the lowest and highest values are given :—

Condenser.	Surface of Plates in sq. cm.	Thickness of Dielectric in cm.	Volts per cm.	Capacity m.f.	Dielectric Constant.
Paraffined paper.....	129,800	0·007	55·500 0·528	5·97 6·01	8·65 8·68
Do.	12,980	0·007	54·400 2·520	0·529 0·55	8·238 8·865
Felten and Guillaume 500-volt concentric paper cable, diam. of core 1·88 cm., length 818 metres		0·22	7·480 0·910	0·045 0·280	2·75 17·12
Crown Glass I.	1,440	0·065	22·900 4·460	0·021 0·0251	10·7 12·8
Crown Glass II.	12,600	0·0198	27·200 1·087	0·40 0·417	6·92 7·22
Megohmit.....	50,600	0·21	5·950 0·286	0·1085 0·113	5·09 5·31
Guttapercha.....	106,000	0·0122	41·000 0·491	2·42 2·50	3·155 3·26

The crown-glass condenser No. I. was made by the author. The plates were washed in ether, heated very slowly to 100° and cooled very slowly, and the whole condenser immersed in oil under a vacuum. The crown-glass condenser No. II. was made by Mengarini with silver-foil; the condenser when built up was heated in a muffle to the melting-point of the glass, so that the edges of the glass plates beyond the silver fused together. It may be seen from the table that paraffined paper shows practically no change in dielectric constant with the slope of potential; megohmit and guttapercha show small changes, glass considerably more, while the Felten and Guillaume paper-insulated cable shows an enormous change, the dielectric constant increasing almost as the slope of potential diminishes. A mica condenser by Elliott Brothers showed no change in the dielectric constant between 5 and 100 volts; the influence of the time of charge was negligible, and the temperature coefficient very small.

The third article deals with the polarisation of the various dielectrics already dealt with, and numerous curves are given for each dielectric at different potentials between the time of charge and the charge. In the paraffined paper condensers the charge increased only some 3 per cent. between 5 and 80 seconds, and at higher potentials only 0·2 per cent.; the discharge was almost complete in 3 seconds. The Felten and Guillaume cable gave similar results. In the glass condensers the time of charge was far longer, and increased with the potential. In the megohmit condenser it was also long, but diminished with the potential. The difference in the quantities at charge and discharge was small, 2 per cent. at most in the

paraffined paper and megohmit condensers, but reached 8 per cent. in the glass condensers.

The last article deals with the energy absorbed in the polarisation period, reckoned from an interval of 5 seconds after commencing the charge. The curve of current and time was taken by a well-damped galvanometer, till the current reached a constant value representing the leakage current of the condenser. The curve was integrated up to this point from the period of five seconds, excluding the constant-leakage current. The result multiplied by the potential was taken as the polarisation energy. The curves of current and polarisation energy with time of charge are given for the various condensers. The following table gives a summary of the results. The column headed "Charge Energy" gives the energy (reckoned from observations with a ballistic galvanometer) in the charge during 5 seconds; the following column gives the ratio of the polarisation to the charge energy. The column headed "Ohmic Energy" gives the energy lost in leakage. The energy is expressed in ergs per cubic cm. of dielectric.

Condenser.	Volts per cm.	Time of Polarisation. Seconds.	Insulation Resistance. Megohms.	Ohmic Energy.	Polarisation Energy.	Charge Energy.	Ratio.
Megohmit	618	200	4,670	0.44	0.94	0.86	1.09
	1,860	220	5,730	5.49	8.12	7.80	1.145
	3,700	140	5,720	18.92	30.10	31.3	0.962
Paraffined Paper	18,400	120	6,820	32.30	8.86	485.0	0.0183
	46,200	130	6,920	216.0	75.3	305.0	0.0247
Crown Glass No. I.	1,980	120	1,970	106.8	28.65	18.57	1.54
	5,980	90	1,980	751.0	99.20	169.5	0.585
	12,000	100	1,545	419.0	676	680.0	0.993
Cable	1,470	80	69,800	0.133	0.184	3.19	0.0527
Guttapercha	8,680	230	1,260	15.8	16.8	106.4	0.158
	18,000	210	945	83.3	61.0	458.0	0.138
Crown Glass No. II.	3,850	600	2	102000	24300	32.3	750

The table shows that the polarisation energy varies from 2 per cent. to 100 per cent. of the charge energy, except in the case of the glass condensers, in one of which it is 750 times the charge energy. The author could find no general law connecting the polarisation energy with the charging potential; assuming it to vary as V^n , n varied from 1.7 to 2.2 in the different condensers. The author is occupied in experiments on the effect of the thickness of dielectric on the polarisation phenomenon, but in the present article only states that this has a marked effect on the form of the discharge curve, the amount of the polarisation energy, and on the loss of energy due to hysteresis.

G. H. B.

73. Insulation Resistance. **A. W. Ashton.** (Phil. Mag. 2. pp. 501-528, Nov., 1901. Paper read before the Physical Society of London, May 81, 1901.)—Confirmation was obtained of Heims' result (Electrician, 25, p. 751, 1890), that a deviation from Ohm's law occurs with cable dielectrics, viz., by giving a greater conductivity with higher pressures on a given thickness. Similar results were given by A. Siemens (Inst. Elect. Engin., Journ. vol. 19, 1890) for rubber, fibre, and guttapercha cables for voltages from 145 to 17,500 volts, and by Leick [see Abstract No. 298 (1899)] for guttapercha, paraffin, and sulphur; but all these tests were made after only a few minutes' electrification. Pure sheet Para rubber, pure rubber (origin other than Para), vulcanised rubber, paraffined paper, and mica were found by the author to deviate from Ohm's law after such electrification that the steady state was reached. Okonite (apparently a vulcanised rubber compound, composition not given) never reached the steady state. The discharge current c varied with the time t according to the curve $\log c = -8.060 - 0.343 \log t$, for the particular okonite cable tested, viz., $\frac{1}{16}$, covered to an outside diameter of 0.208 inch and 2,760 feet long. Experiments on a paraffin paper condenser and the above okonite cable show that the charging current varies with time according to the formula $C - C_0 = At^{-x}$ where C is the charging current, A and x are constants, and t is the time in seconds since electrification commenced. When t is very great, $t^{-x} = 0$, and the current becomes constant and $= C_0$. This may, therefore, be a current due to true conduction, while the variable part At^{-x} may represent the energy which is slowly absorbed by the condenser; the ratio of the charging pressure to C_0 is the true resistance. C_0 could not be obtained for okonite, but the author concludes—(1) That the current during the first hours of electrification increases when the pressure is increased [more rapidly than proportionally to the pressure]; (2) that this does not necessarily prove the okonite not to follow Ohm's law, as the true conduction current C_0 must be less than the total current unless electrification is continued for very long periods; (3) that the charging current is a power function of the time, and on this may be superposed the true conduction current. Other experiments were made which showed that the only deterioration in rubber due to moderate alternating pressures (2,400 volts) was in the case of pure Para, and due to ozone, or other gases generated by alternating stress, attacking the rubber. Breakdowns generally occurred at the edges of the sheets of tin-foil.

M. O'G.

74. Dielectric Strain. **L. T. More.** (Phil. Mag. 2. pp. 527-531, Nov., 1901.)—More here replies to Sacerdote, justifying the accuracy of his own method and apparatus, and discussing the results of Quincke, Cantone, and Sacerdote. The evidence as to the existence of any elongation of glass tubes when electrically charged is very conflicting, and, by reason of probable errors, doubtful. The tube tends to bend by electrostatic attraction; the elongations are too close to the limits of the apparatus to establish a law when the existence of the effect is in doubt; the change of length on charging is quite different from that on discharging, and the difference is erratic; and the greater the precautions taken against errors and extraneous effects, the less the amount of the elongation. [See also Abstracts Nos. 2440 (1900) and 1820 (1901).]

A. D.

75. Galvanometer of High Sensibility. **C. E. Mendenhall and C. W. Waldner.** (Amer. Journ. Sci. 12. pp. 249-262, Oct., 1901.)—The authors describe, with scale diagrams, a Thomson galvanometer, presenting new

features in certain details. The paper, however, deals chiefly with experiments on galvanometer magnets, made to determine their best size, shape, and material. The magnetic moments of the small magnets were measured by mounting them on small brass discs, and oscillating them in vacuo. The following are the results obtained: The limiting intensity of magnetisation is reached in a field of 1,000. For short magnets the magnetic moment decreases more rapidly than in proportion to the length. The intensity of magnetisation increases as the cross-section of the magnets; this means that there would be a gain in sensibility by using several small magnets over one of their united cross-section, provided, however, that the magnets are not greatly weakened by their mutual action. Measurements made to determine this latter question showed only a small weakening due to mutual action, of about 5 per cent., when the magnets were 1 mm. apart, increasing to 19 per cent. when they were in contact. As regards the quality of steel, watch hair-spring was found to be the best material, after a special magnet steel, probably tungsten steel, which gave moments 25 per cent. greater. The effect of jars or shocks on the magnetic moment is negligible; boiling in water reduces it by 10 per cent. to 15 per cent., most of this loss occurring in the first few minutes of boiling. The sensibility of a galvanometer increases with the ratio of magnetic moment to moment of inertia, and Paschen showed that the sensibility increased inversely as the square of the length of the magnet; making allowance for the fact that the magnetic moment is not proportional to the length, the authors show that the sensibility increases more nearly as the length diminishes. Further, taking into account the moment of inertia of the non-magnetic material of the system, they show that a maximum sensibility is reached for magnets of a certain length, which, in a particular case considered, was found to be 1.1 mm.

The paper concludes with a table giving the constants of the most sensitive galvanometers made. That constructed by the authors gives 6,090 mm. deflection per microampere at 1 metre with a period of 10 seconds and resistance of 1 ohm. G. H. B.

76. Hot-wire Ammeters and Voltmeters. A. Soulier. (Ind. Élect. 10, pp. 474-476, Oct. 25, 1901.)—The article describes the hot-wire instruments made by Chauvin and Arnoux. They are provided with a compensating device for variations of outside temperature. The ammeters consist of a low-resistance voltmeter, giving full deflection for 0.15 volt, and a shunt of material with low temperature coefficient. The shunts are all interchangeable. G. H. B.

77. New Form of Potentiometer. P. Heyck. (Elektrotechn. Zeitschr. 22, pp. 871-874, Oct. 17, 1901.)—This is a description of an improved type of compensation apparatus designed by Professor Thiermann, and in use in the standardising-room of the Hanover Technical High School. Measurements of voltages from 0.001 to 1,000 can be made with it, with an accuracy of 0.1 per cent. A Weston cell is used as a standard, and its e.m.f. can be balanced against any other by a series of resistances arranged in dials. The apparatus can also be used as a Wheatstone Bridge. Diagrams of connections and photographs are given. W. W. H. G.

78. Mercury Jet Interrupter. R. H. Cunningham. (Elect. World and Engineer, 88, pp. 588-589, Oct. 12, 1901.)—The paper describes a new form of mercury jet interrupter for induction coils, to be driven by an electric motor. The mercury issues under centrifugal force from two tubular arms, and is raised again from the well by an archimedian screw. G. H. B.

ALTERNATING CURRENTS AND MAGNETISM.

79. *Fallacies Connected with some Recent Alternating-Current Inventions.*

P. Bunet. (*Ind. Élect.* 10. pp. 472-474, Oct. 25, 1901.)—A number of recent patents which have come under the author's notice appear to be based on the following fallacy: "Imagine a gramme ring with a commutator, and suppose that by applying brushes to various points of the commutator a system of polyphase currents is supplied to the winding, the angular distances between the different brushes corresponding to the phase-differences between the currents. A rotating magnetic field will thereby be produced, and as this sweeps across the conductors it gives rise to a reactance e.m.f. But now suppose that the ring itself is rotated synchronously in the direction of the field, or that while the ring is stationary the brushes are rotated in a direction opposed to the rotation of the field; then the field will become stationary with respect to the windings, and hence the reactance e.m.f. will disappear, the ring behaving to each current as if it had resistance only." The author exposes the fallacy of this reasoning, and shows that such rotation, so far from suppressing the reactance e.m.f., would only give rise to further trouble on account of the violent sparking at the brushes.

A. H.

80. *Effects Produced by Alternating Currents in Ring Armatures.*

M. Leblanc. (*Écl. Électr.* 29. pp. 113-117, Oct. 26, 1901.)—The author criticises deductions sometimes drawn from the theorem that it is possible with alternating currents of frequency f to produce a nearly steady magnetic flux in a ring armature by the simple expedient of making the brushes rotate backwards round the commutator with an angular velocity $2\pi f$. It is erroneously deduced, for example, that since the flux is constant the applied p.d. has only to overcome the ohmic resistance of the windings of the armature. He points out that at any instant the coils between consecutive brushes act like the primary windings of a polyphase transformer on the coil or coils short-circuited by the brushes. The currents in these short-circuited coils are, comparatively speaking, small, and hence there is a decided phase-difference between the applied p.d. and the current in the coils between consecutive brushes. He concludes that if we send n polyphase currents through a ring armature by means of n brushes separated from one another by angles $\frac{2\pi}{n}$ then the counter e.m.f.'s developed between the brushes which determine the magnitude of the currents in the coils are exactly the same, whether the brushes are fixed, or whether they rotate round the commutator. He gives quotations from a paper of his own published in the *Comptes Rendus* for July 29, 1889, showing that he then realised the importance of the applications of the use of a ring armature with alternating currents.

A. R.

81. *König's Manometric Flames for Studying Changes in Wave-form of Alternating Current.*

R. Weber. (*Ann. d. Physik*, 6. 3. pp. 565-569, Nov., 1901.)—The membrane of the chamber through which the gas passes on its way to the burner carries in its centre a short soft-iron cylinder, 1 cm. in diameter and 0.2 cm. long. This is placed in front of the laminated core of an electromagnet, whose coil is 5 cm. long and wound with 3,000 turns of fine wire to a resistance of 280 ohms. The laminated core is polarised by being placed in contact with one end of a permanent bar magnet 25 cm. long. The flame is viewed in a rotating mirror. The method does not give the

actual wave-shape, but changes in the wave-shape may by its aid be rendered visible. Specimens are given of several flame-pictures corresponding to different wave-shapes. A. H.

82. *Phase-swinging and Theory of Damping Coils.* W. M. Thornton. (Electrician, 47. pp. 870-872, Sept. 27, and pp. 914-916, Oct. 4, 1901.)—The author plots a polar diagram in which the vectorial angle represents the angle of phase-difference, and the radius vector the power (or the torque, to a different scale). He then shows that an elementary arc of the curve so obtained represents the work done during a slow change from the one phase angle to the other, when the variation of load is gradual. If, on the other hand, the change of load is sudden, the work done during the rapid change of phase is greater, the additional amount of energy being supplied by the kinetic energy of the armature. Oscillations are thereby set up. Assuming that there is no damping, the author writes down the differential equation corresponding to the oscillations, and finds the period. He next considers the more complicated case in which damping coils are used, taking first the damping due to dissipation of energy in the coil itself, and then that due to dissipation in the core. The paper concludes with some general remarks on the effect of phase-swinging on the generator, and flywheel design. A. H.

83. *Phase-angle Measurement.* A. S. M'Allister. (Elect. World and Engineer, 38. p. 849, Nov. 23, 1901.)—The author describes a method of measuring the angle of lag in three-phase circuits by one wattmeter.

The wattmeter is inserted in one line, and two readings taken, with the shunt coil connected between that line and each of the others. If W_1 and W_2

are the two readings, $\tan \phi = \sqrt{3} \cdot \frac{W_1 - W_2}{W_1 + W_2}$.

The voltages on the two circuits must be equal, or else one reading must be corrected to such a value as would have been obtained had they been equal. As a ratio only is required, the wattmeter need not be calibrated. If the circuits be equally loaded, the sum of the readings gives the real power, and the difference the wattless power. G. H. B.

84. *Theory of Magnetic Induction.* J. Buchanan. (Phil. Mag. 2. pp. 456-462, Nov., 1901.)—This is a continuation of the work referred to in Abstract No. 1585 (1901). Two hysteresis curves are taken from Ewing's papers, viz., for annealed iron and for hardened iron. These curves are subjected to the harmonic analysis, and thus an application of the general theory stated in the previous paper is obtained. The first three harmonic constituents are determined in each case, and numerical values for the constants are given. The work of the paper is mainly analytical. J. W. P.

85. *Hysteresis in Iron, Measured Statically, and in Alternating and Rotating Fields.* A. Dina. (Elettricità, Milan, 20. pp. 614-616, Sept. 28; 628-629, Oct. 5; and pp. 663-665, Oct. 19, 1901. Paper read before the R. Istituto Lombardo di Scienze e Lettere.)—The author employed iron wire of poor quality, and measured its hysteresis statically, i.e., by the ordinary method with a ballistic galvanometer, and also in an alternating and in a rotating field.

The measurements in a rotating field formed the subject of a previous paper by the author [see Abstract No. 2050 (1900)], and the measurements in

an alternating field which are described in the present paper, were undertaken on the same sample of iron for comparison with the previous results. The method employed was to take the current and pressure curves in the magnetising coil; the power spent in the coil, which consists of the ohmic loss in the coil, and the hysteresis in the iron can be calculated from these. The frequency adopted was $40 \sim$, or double that in the case of the rotating field. The hysteresis in a rotating field was found to be lower than that in an alternating field, the difference increasing from 4 per cent. at $B = 7,000$ to 15 per cent. at $B = 18,000$. The hysteresis in an alternating field was uniformly higher than that measured statically, the percentage difference being constant at 7.8 per cent. in the limits of measurement, from $B = 4,000$ to $B = 18,000$. The permeability to alternating current was less than that measured statically, the percentage difference varying from 18 per cent. at $H = 7.5$, $B = 4,760$, to 8.5 per cent. at $H = 50$, $B = 18,000$. G. H. B.

86. Variation of Hysteresis with Induction. H. Maurach. (Ann. d. Physik, 6. 3. pp. 580-589, Nov., 1901.)—The author undertook experiments on a sample of transformer iron, to find the variation of the exponent in Steinmetz's formula $W = \eta B^x$. Measurements were made by the ballistic method.

The exponent x was found to decrease as the induction increased; from $H = 0.8$ to $H = 8$ there was a rapid fall from 2.47 to 1.94; from $H = 8$ to $H = 12$ the fall was slower to 1.83; and from $H = 12$ to $H = 28$, it was still slower, the lowest value being 1.22. G. H. B.

87. Variations of Magnetisation in Cubical Crystals. Wallerant. (Comptes Rendus, 138. pp. 680-682, Oct. 21, 1901.)—Weiss has shown experimentally that the induction in the interior of a crystal of magnetite placed in a uniform field, varies with the direction of this field. The author of this note establishes the relations existing between this induction and the direction of the field, on the supposition that the induction is uniform in the crystal. J. J. S.

88. Magnetic Expansion of Iron. E. Rhoads. (Phil. Mag. 2. pp. 468-468, Nov., 1901.)—A narrow strip of sheet tinned iron, 21 cm. long, is taken. To each end of the central 7 cm. a tube is clamped. These tubes are concentric and end near one another, so as to actuate a system of levers and optical lever. Also by constructing one tube of brass and platinum, and the other of brass only, temperature compensation is made. The system is fitted within a coil 24 cm. long, water jacketed on the inside, and the whole is suspended by rubber to avoid vibrations. Smooth hysteresis curves, such as Nagaoka first obtained, are found. The results obtained are—(1) Change in diameter probably does not affect the shape of the curves. (2) Small changes occur in the curve if the specimen be removed and returned to its place, apparently exactly as before; this is not yet explained. (3) Annealing causes higher maxima; shearing causes lower maxima, corresponding to the softening and hardening of the substance. P. E. S.

89. Longitudinal Thermomagnetic Effect. G. Moreau. (Journ. de Physique, 10. pp. 685-691, Nov., 1901.)—Let a wire or sheet of bismuth be arranged in a magnetic field normally to the lines of force, supposed horizontal, and let a vertical flow of heat be established in the metal. Under the action of the field there is produced parallel to the flow of heat an e.m.f.

independent of the *sense* of the field. This longitudinal thermomagnetic effect is totally different from the transversal thermomagnetic effect analogous to the Hall effect.

After describing briefly the experiments carried out by Lownds on bismuth [see Abstracts Nos. 1680 and 2158 (1901)], the author gives an account of his own researches on the magnetic metals nickel, soft iron, and soft steel. On plotting curves with the thermomagnetic effect n as ordinate, and the strength of field as abscissa, it is noticeable that a point of inversion occurs in each case. The value of n first decreases as the field is made stronger, then reaches a minimum (which differs for each metal), and next rises, at first rapidly, attaining a positive value, and then more slowly. The curves are analogous to those obtained in the case of bismuth, but may be said to be opposite in sign, as for bismuth there is first a rise to a positive maximum, and then a decrease to a negative value.

In considering the interpretation of the results the author refers to the investigations of Houllevigue [Ann. de Phys. et Chim. 7. 1896], according to which the Thomson effect in a magnetic metal varies with the longitudinal magnetisation. Between two successive sections at the temperatures T , and $T + dT$, the magnetisation introduces a difference of potential

$$dh_1 = \sigma_1 dT,$$

where σ_1 is the change in the specific heat of electricity σ under the action of H .

According to Houllevigue, between two successive sections of a metal unequally magnetised, there is a difference of potential

$$dh_2 = \lambda dH,$$

where λ is a coefficient analogous to σ_1 ; it is a function of H and of T . Like σ_1 it does not change sign with H .

The same coefficients can be defined for the transversal magnetisation. On evaluating the fall of potential under the action of the field in the vertical branch of the sheet or wire with its flow of heat, then—

$$V_B - V_A = \int_{t_a}^{t_b} \sigma_1 dT + \int_0^H (\lambda - \lambda_1) dH.$$

Here t_a and t_b are the temperatures at two neighbouring points a and b in the unequally heated metal, a being at a higher temperature than b , and the portion between these points being placed in a magnetic field: λ refers to one portion of the wire above a , and λ_1 to another part below b when the field varies. But λ is greater than λ_1 , for the coefficients σ_1 and λ increase with the temperature.

According to Houllevigue, σ_1 is negative if H is inferior to 250 units. This number refers to longitudinal magnetisation; it must be raised if the sheet is magnetised transversally. Besides, $\lambda - \lambda_1$ is negative and feeble for small fields; then $V_B - V_A$ is first positive, and changes sign for a value of H which depends on the mean temperature of the plate. The longitudinal thermomagnetic current will flow, first with the flow of heat, and then against it, through the exterior circuit.

The author's general conclusion is that the thermomagnetic longitudinal effect may be regarded as resulting from a modification of the thermoelectric elements.

J. J. S.

ELECTROPHYSIOLOGY.

90. Skin Currents: Frog's Skin. A. D. Waller. (Roy. Soc., Proc. 68. pp. 480-494, Sept. 27, 1901.)—The normal current is ingoing (from the outer surface inwards) and is greater the more lively the skin. Under a direct excitation (mechanical, or by single induction shocks, by a series of alternating induction shocks or by condenser discharges), the response is an outcoming current, which is greater the greater the excitation, and is greater when the exciting discharge passes inwards, and also presents the phenomena of summation and of fatigue; it is abolished at temperatures above 45° or below 6°, and by mercuric chloride. Under indirect excitation through the nerves of a nerve-skin preparation, the most normal response is an outcoming current; the most enduring is an ingoing current; and in some cases we have the one or the other, followed or interrupted by the opposite current. The interval of time between the excitation of the nerve and the electrical response of the skin is about two seconds. The electrical conductivity of living skin is greatly augmented both by direct excitation and by indirect excitation through nerve. Atropine directly applied to the skin abolishes the effect of indirect excitation. The electrical response of the skin to direct electrical excitation is at or near its external surface. Bibliographical notes as to the history of the question are given in the paper. A. D.

91. Blood-compounds in Magnetic Field. A. Gamgee. (Roy. Soc., Proc. 68. pp. 508-512, Sept. 27, 1901.)—It is known that blood is strongly diamagnetic, and the blood corpuscles more diamagnetic than the liquid in which they float. The author now finds that oxyhæmoglobin, CO-hæmoglobin and methæmoglobin are strongly diamagnetic, but that hæmatin and acethæmin (hæmin) are strongly magnetic. This led to electrolytic experiments in which it was found that solutions of pure oxy-hæmoglobin under electrolysis promptly precipitate their oxyhæmoglobin in a form still soluble: that solutions of CO-hæmoglobin do the same; that, on continuing the current, secondary reactions occur, from which it is probable that in the blood-colouring matter the iron-containing group on which its physiological properties depend, is, or is contained in, an electronegative radical. According to analogy the iron in such a compound would possess diamagnetic and not magnetic properties. A. D.

REFERENCES.

92. Magnetic Effect of Electric Convection. H. A. Wilson. (Phil. Mag. 2. pp. 319-320, Sept., 1901.)—This is a further criticism of Crémieu's experiments on this subject. [See Abstracts Nos. 2188 and 2189 (1901).] W. C. H.

93. Development of the Electron Idea. W. Kaufmann. (Phys. Zeitschr. 3. pp. 9-15, Oct. 1, 1901. Paper read before the 73 Naturforscherversammlung at Hamburg. Translation in the Electrician, vol. 48. pp. 95-97, Nov. 8, 1901.)

94. Values of the Terrestrial Magnetic Elements at Potsdam for 1900, and of the Secular Variations from 1890 to 1900. M. Eschenhagen. (Ann. d. Physik, 6. 2. pp. 424-427, Oct., 1901. Communicated by the Königl. Preuss. Meteorolog. Instituts.)—The paper contains a brief summary of observations at the magnetic observatory of the Royal Prussian Meteorological Institute.

CHEMICAL PHYSICS AND ELECTRO-CHEMISTRY.

95. *Mathematical Expression of the Periodic Law.* S. H. Harris. (Journ. Phys. Chem. 5. pp. 577-586, Nov., 1901.)—Comparing Venable's table of the elements with a table of the atomic weights, the author deduces various numerical relations. In particular, calling the series Li, Be, B, C, N, O, F, bridge elements and Na, Mg, Al, Si, P, S, Cl, typical elements, he states the approximate law that the ratios of the logarithms of the atomic weights of bridge elements and typical elements, which stand next to them in the table, decrease in a certain geometrical progression as we pass from the left, or positive, side of the table toward the central carbon atom, and increase as we pass from the carbon atom toward the right, or negative, end of the table: The relations deduced are used for estimating the atomic weights of missing elements.

W. E. T.

96. *Reversion of Flames.* E. Mameli and M. Comella. (Accad. Lincei, Atti. 10. p. 199, Sept. 15, 1901.)—An arrangement is described for producing a flat disc of flame in which the one side presents gas burning in air and the other side air burning in gas.

A. D.

97. *Uranium and its Compounds.* J. Aloy. (Annal. Chim. Phys. 24. pp. 412-432, Nov., 1901.)—The author gives an account of his researches on (1) the preparation of uranium; (2) uranous and uranic salts, and (3) the determination of the atomic weight of uranium, the method employed being the measurement of the volume of nitrogen and of the weight of oxide obtained from a given weight of uranium nitrate. The mean value found for the atomic weight of uranium, taking oxygen as 16, is 239.40. The numbers obtained by previous observers are given.

T. H. P.

98. *Sulphuric Anhydride and Disulphuric Anhydride.* G. Oddo. (Accad. Lincei, Atti. 10. pp. 207-217, Nov. 3, 1901.)—The connection between the liquid and crystalline forms of what is usually known as sulphuric oxide, or as sulphur trioxide, has up to the present time never been clearly established. In the present paper it is shown by cryoscopic determinations of the molecular weight in phosphorus oxychloride solutions, that the solid form, S_2O_6 , is a polymer of the liquid modification, SO_3 .

D. H. J.

99. *Specific Volume as an Indication of Chemical Combination in Alloys.* E. Maey. (Zeitschr. Phys. Chem. 38. pp. 292-306, Sept. 17, 1901.)—The existence of definite chemical compounds in alloys or mixtures of two or more metals can, in general, only be deduced from a series of determinations of some quantitative property which is a continuous function of the composition of the alloy. For this purpose the melting-point, heat of combination, electrical properties, &c., have been employed, and the use of the specific volume is now advocated. The examination of published results shows that there is no evidence of the existence of compounds in the case of bismuth-antimony, bismuth-tin, cadmium-tin, lead-tin, lead-silver, silver-copper, gold-copper, gold-silver, gold-tin, iridium-platinum, bismuth-cadmium, silver-bismuth, mercury-lead, mercury-tin, tin-antimony, tin-zinc, lead-cad-

mium, and lead-antimony alloys—a conclusion which is in accord with the results obtained by other methods. On the other hand, the investigation of some other alloys yielded results, which are given in the paper in the form both of tables and curves, indicating the existence of the compounds SnAg_3 , Au_3Bi_3 , Au_3Pb_3 , BiPb or Bi_3Pb_3 , FeSb , SnCu_3 , and CuZn_3 . N. L.

100. *Volume and Density Changes produced in Liquids by Absorption of Gases.* E. Wenzel. (Ann. d. Physik, 6. 8. pp. 520–582, Nov., 1901.)—The author gives the results of an examination of the increase of volume of water, caused by its absorption of different proportions of hydrogen, oxygen, carbon dioxide, sulphur dioxide and ammonia. From these numbers the density of each gas as it exists in solution can be calculated. These densities are given in the following table for solutions containing different proportions of the amount of gas present in a saturated solution:—

Percentage.	SO_2	CO_2	O	NH_3	H
10.....	2.5825	1.2904	1.2604	0.7526	0.0782
20.....	2.8985	1.8007	1.2582	0.7606	—
30.....	2.8245	1.8024	—	0.7658	0.0786
40.....	2.2836	—	1.2831	0.7699	—
50.....	2.2548	1.8050	1.2671	0.7739	0.0776
60.....	2.2302	1.8041	—	—	0.0782
70.....	2.2096	1.8050	1.2705	—	—
80.....	—	1.8067	1.2615	—	0.0788
90.....	—	1.8033	—	—	0.0784
95.....	—	1.2990	1.2626	—	—

The densities of the liquefied gases, according to Landolt and Börnstein's Tables, are: SO_2 , 1.4836 (at 0°); CO_2 , 0.9471 (at 0°); O, 0.7555 (at -129.5°); NH_3 , 0.6364 (at 0°); H, 0.025 (at 275 atmospheres pressure). It is evident that there exist very large attractive forces between the separate molecules of a gas in solution, the magnitudes of which are from 2,500–8,000 atmospheres; it is probable that these forces depend on the chemical nature of the gas as well as on its physical properties. The author's results show that the law of proportionality between increase of volume of the liquid and amount of gas absorbed holds perfectly for gases which are only absorbed to a slight extent, whilst for the more soluble gases this is not the case. T. H. P.

101. *Specific Volume of Liquids at Infinite Pressure.* S. Pagliani. (Accad. Lincei, Atti, 10. pp. 69–74, 1901.)—From the equation of van der Waals, reduced to its simplest form for the case of a rarefied gas, Tumlirz [see Abstract No. 622 (1901)] deduced the relations—

$$(1) \dots \dots -\frac{1}{v} \left(\frac{\partial v}{\partial p} \right)_T = 12.225m \frac{(v-a)^2}{Tv},$$

and—

$$(2) \dots \dots (v_1 - v_n) = 12.225m \frac{(p_1 - p_n)(v_1 - a)(v_n - a)}{T},$$

v being the volume in c.m. of a kilogramme of the gas, m its molecular weight, p the pressure in atmospheres, v_1 and v_n the specific volumes corresponding with the pressures p_1 and p_n , and a the constant of van der Waals' equation. Expression (1) gives the coefficient of compressibility of the liquid, whilst the constant a is obtained from (2). The values calculated from these equations for the compressibilities of a number of liquids do not

show good agreement with the values experimentally obtained by several observers, and the author considers the deviations to be due to the fact that a varies with the temperature. He has calculated the values of a at various temperatures for a number of liquids, and finds that in general they tend to increase as the temperature is raised, except in the case of ethyl ether, where a decrease occurs; with this ether, too, the ratio of the coefficient of compressibility at 100° to that at 0° is more than 8, whilst with the other liquids examined it is always below 2. In the following table, the values of a are given, together with n , the number of atoms in the molecule, and ma , the product of the molecular weight into the constant a :—

	n	a	ma
Mercury	1	0.00006798	0.018595
Water.....	3	0.00074578	0.018423
Carbon disulphide	3	0.00064052	0.048680
Ethyl alcohol	9	0.0009970	0.045862
Propyl „	12	0.0010199	0.061194
isoButyl „	15	0.0010429	0.077175
Amyl „	18	0.0010517	0.092550
Ethyl ether	15	0.0011025	0.081590
Benzene.....	12	0.0009593	0.074825
Toluene	15	0.0009865	0.090758
Xylene	18	0.0010061	0.106647
Cymene	24	0.0010240	0.187216

From these numbers it is seen that, in general, the minimum specific volume a , assumed by a liquid under infinitely great pressure, increases with the complexity of the molecule. Further, the values of the product ma , which are proportional to the molecular volumes, and hence also the values of $\sqrt[3]{m.a}$, which are proportional to the diameters of the molecules, stand in relation to the molecular complexity.

T. H. P.

102. *Physics of Water.* G. F. Stradling. (Frank. Inst., Journ. 152. pp. 257–268, Oct., 1901.)—Röntgen's theory that water contains two kinds of molecules, which he designates "ice molecules" and "molecules of the second kind," has been worked out quantitatively by Sutherland [see Abstract No. 404 (1901)], and promises to explain many points in which water behaves in an exceptional manner. In addition to the well-known maximum density at 4°C. , the minimum of compressibility at 68°C. , the decrease by increasing pressure of the coefficient of thermal expansion, the lowering by increased pressure, and by dissolved salts, of the temperature of maximum density, the influence of pressure and temperature on the viscosity of water, the decrease of volume in preparing aqueous solutions, and the low specific heat of solutions as compared with water, can also be explained. "Not only in the matter of solutions, but in other more strictly physical relations, it is a misfortune that the rôle of the typical liquid was assigned to water."

T. M. L.

103. *Pyrogenic Reactions and Electric Synthesis.* W. Löb. (Zeitschr. Elektrochem. 7. pp. 903–921, Oct. 8, 1901.)—This first instalment deals with chloroform and carbon tetrachloride. By an apparatus figured and described, the compounds are vaporised in a flask containing a spiral of iron, nickel, platinum, or platino-iridium wire heated by an electric current, and the

products, liquid and gaseous, are collected. The temperature of the wires is measured by their resistance. At 850° – 950° C., chloroform, besides HCl, yields C_2Cl_4 , C_3Cl_6 , C_6Cl_6 (hexachlorbenzene) and CO, air being present. A mixture of the vapours of chloroform and aniline, carried over by steam, gave the above products and aniline hydrochloride: on saturating the residue with ammonia, triphenyl-guanidine, $C_{18}H_{17}N_3$, was obtained. Carbon tetrachloride yields a large quantity of free chlorine, with CO, from water present, and a little carbonyl chloride; the residue containing C_2Cl_4 , C_3Cl_6 , and C_6Cl_6 . When this is mixed with air much carbonyl chloride is formed. Similar reactions are obtained with perchlorethylene, C_2Cl_4 . The author is further developing this process of treating the vapours of different substances along with chloroform or CCl_4 as a valuable and simple method of synthesis. The different possible reactions are discussed at some length. S. R.

104. *Melting-points of Reciprocal Pairs of Salts.* W. Meyerhoffer. (Zeitschr. Phys. Chem. 88. pp. 807–825, Sept. 17, 1901.)—The author describes experiments on the melting of mixtures of two salts, for example potassium chloride and sodium bromide, which do not form an isomorphous mixture, or a double salt. From the occurrence of one or several melting points it can be seen which of the two pairs, $KCl + NaBr$, and $KBr + NaCl$, is stable. When equivalent quantities of barium sulphate and potassium carbonate are fused together, the transformation into barium carbonate and potassium sulphate is complete when equilibrium is attained, as the author's melting-point measurements show that this pair is stable. It is uncertain whether this mixture melts without separation of barium sulphate, but such separation is, at most, very small. These results are contradictory to those of Rose, who stated that an excess of potassium sulphate hinders the reaction between potassium carbonate and barium sulphate. The question of the synthesis of minerals by double decomposition is also discussed. T. H. P.

105. *Partially Miscible Liquids Near the Critical Point.* J. Friedländer. (Zeitschr. Phys. Chem. 88. pp. 385–440, Oct. 1, 1901.)—The saturation-point of mixtures of water and isobutyric acid can be determined within 0.01° – 0.02° , provided that the composition of the mixture does not differ by more than 10 per cent. from the critical proportions; the temperature at which the liquid becomes milky on cooling is usually 0.02° below that at which it becomes clear on warming, and the mean of these two temperatures is taken at the saturation-point; the saturation-point is, however, greatly affected by the purity of the preparations, and was found to be 0.9° lower for a specimen of isobutyric acid recovered from the aqueous mixtures, than for the original acid. Solutions which have approximately the critical composition exhibit a bluish opalescence at temperatures up to 10° above the well-defined saturation-point; unlike a colophonium emulsion, however, this opalescence is not affected by time, and the volume, electrical conductivity, and internal friction of the liquid remains constant during a number of hours.

The temperature coefficient of internal friction increases very greatly in the neighbourhood of the critical point, the maximum value observed being as high as 84.8 per cent. per deg. C. for a mixture of isobutyric acid and water of the critical composition (88.60 per cent. acid), and within 0.15° of the critical temperature (25.80° C.); it falls to 7.0 per cent. at 1° above the critical temperature, and to 3.0° at 10° above; similarly mixtures containing 20 per cent. more or less of the acid have a temperature coefficient of only

8.5 per cent. per deg. C. Similar observations were made with mixtures of phenol and water, and with ternary mixtures of benzene, water, and acetic acid.

Precisely similar results were obtained on studying the opalescence phenomena referred to above. Quantitative determinations were made by means of a colorimeter, and it was found that in mixtures of isobutyric acid and water the opalescence reached a maximum of 69 units for a critical mixture 0.04° C. above the critical temperature, and falling to 4.5 units at a temperature 1° above; the value also fell to 18 units for a solution containing 4.5 per cent. less acid at a temperature just above its saturation-point, and to 10 units for a solution containing 6.8 per cent. more acid. Entirely opposite results were obtained on studying the density, coefficient of expansion, electrical conductivity, and refractive index of the solutions; these change quite continuously in the neighbourhood of the critical-point, and do not exhibit maxima or any other abnormal features.

T. M. L.

106. *Polymolecular Chemical Reaction.* A. Schükarew. (Zeitschr. Phys. Chem. 38. pp. 353-368, Sept. 17, 1901.)—The velocities of the following reactions have been investigated for the purpose of determining the number of molecules taking part in each reaction:— $\text{FeCl}_3 + \text{KI}$; $+ \text{NaI}$; $+ \text{CaI}_2$; $+ \text{SrI}_2$; $\text{Fe}_2(\text{SO}_4)_3 + \text{NaI}$; $+ \text{CaI}_2$; $+ \text{ZnI}_2$; $\text{CrO}_3 + \text{NaI}$ in presence of H_2SO_4 ; $+ \text{ditto}$ in presence of HNO_3 ; $\text{CrO}_3 + \text{SrI}_2$ in presence of HNO_3 ; $\text{HNO}_3 + \text{NaI}$; $\text{HNO}_3 + \text{CaI}_2$. In the case of ferric chloride and the iodides, the action appears to be monomolecular with respect to iron salt (or ion), and bimolecular with respect to the iodide. Ferric sulphate appears to react with a coefficient smaller than unity: this is ascribed to hydrolysis as a possible cause. CrO_3 enters into reaction with one molecule, the acids with the coefficient 2-2.2, while in this case the iodides give varying coefficients.

F. G. D.

107. *Minimum Value of Heat of Combination.* de Forcrand. (Comptes Rendus, 133. pp. 681-684, Oct. 28, 1901.)—In this paper the author pursues further the analysis begun in an earlier paper [see Abstract No. 1497 (1901)], and produces a table giving calculated minimum values of the total heat of combination for a number of different bodies. These values have been compared with numerous results actually known in thermo-chemistry, and in many cases a striking verification has been obtained. In no case, excepting some exceptions which are readily explained, have values been found lower than those given in the table. The author therefore believes that his figures give, within 6 or 7 per cent., the true minimum values of the total heat of combination.

W. C. H.

108. *Specific Heat of Solutions.* K. Puschl. (Akad. Wiss. Wien, Sitz. Ber. 109. IIa. pp. 981-991, 1900.)—The specific heats of some solids and liquids may be calculated by assigning a certain atomic heat to each element, and dividing the sum of atomic heats by the sum of atomic weights. Several cases are worked out. Now, since the specific heat of ice is half that of water, and the specific heat of an aqueous solution is always smaller than the value calculated from the specific heats of the constituents, the discrepancy may be explained by assuming that the specific heat of water decreases in the solution. It is shown that for a large number of aqueous (electrolytic) solutions the product—specific heat $\times$ sum of atomic weights is less than the calculated atomic heat, taking specific heat of water = 1, by a number which

is a multiple of 9, i.e., the atomic heat of part of the water is reduced from 18 to 9. For example, $\text{KHO} + 30\text{H}_2\text{O}$ has specific heat 876, atomic heat 558 ($18 + 30 \times 18$), and sum of atomic weights 596: now $558 - 876 \times 596 = 35.9$, or nearly 4×9 , as if the solution contained the hydrate $\text{KHO} + 4\text{H}_2\text{O}$, in which the specific heat of the water had the value 0.5. Many other examples are given, some substances, e.g., NaHO , requiring a value 4.5 for the specific heat of the modified water. G. E. A.

109. *Heat of Formation of Carbides and Silicides of Iron.* E. D. Campbell. (Electro-Chemist, 1. pp. 231-233, Sept., 1901. Abstract of a paper read before the Iron and Steel Institute, May, 1901.)—The heat of formation of carbide of iron is $\text{C} + 3\text{Fe} = \text{CFe}_3 + 8494$ cal. or 47 calories per gm. of carbide; that of silicide of iron is $\text{Si} + 3\text{Fe} = \text{SiFe}_3 + 26136$ cal., or 133.1 calories per gm. of silicide. The heat of solution of iron and steel is not appreciably affected by annealing or similar processes unless this alters the solubility of the carbide, or of the phosphorus contained in the metal. T. M. L.

110. *Heat Produced in the Reaction between Oxygen and Potassium Pyrogallate.* Berthelot. (Comptes Rendus, 133. pp. 664-666, Oct. 28, 1901.)—There is considerable evolution of heat, which falls off (per gm. molecule of oxygen absorbed) as the reaction progresses. The results obtained at a temperature of reaction of 22°C . are:—

Amount of O absorbed as percentage of total amount absorbable.	Heat evolved in calories per 16 grms. of oxygen.
2.8 per cent.	+ 60.2
6.6 "	+ 50.0

F. G. D.

111. *Action of Ammonia on Metals at High Temperatures.* G. T. Beilby and G. G. Henderson. (Chem. Soc., Journ. 79. and 80. pp. 1245-1256, Nov., 1901.)—Ammonia is rapidly decomposed when passed through an iron tube heated to 800° , but the iron becomes as brittle as hardened steel, so that it can be shattered by a blow with a hammer; the iron shows a bright silvery fracture, and under the microscope exhibits a spongy fracture. Copper decomposes ammonia less readily than iron, but is even more profoundly altered; after exposure to ammonia gas for a few hours at 800° , a copper tube becomes so brittle that it cannot bear its own weight without breaking; the copper swells very greatly, and observation with the microscope shows that the copper has become spongy and disintegrated throughout; it retains its colour, and, to a certain extent, its metallic lustre, but appears as if it had been in the fluid state, and blown up into a sponge by innumerable minute gas-bubbles. Many other metals are similarly acted upon, their appearance under the microscope indicating that the action of the ammonia has produced a certain degree of fluidity. When wires of different metals were twisted together, and heated in a current of ammonia, they were found in many cases to have flowed together; thus iron and copper, iron and gold, gold and platinum, gold and silver, became fused together; in the case of iron and gold the gold sometimes flowed over the surface of the iron, forming a complete plating.

These effects are shown to be due to the formation of nitrides, which are only stable in presence of a large excess of ammonia and within certain

limits of temperature; in some cases a marked increase in weight occurs, but usually the weight of the metal remains unaltered, although its structure is profoundly altered by the formation and decomposition of the unstable nitrides. The action proceeds with extraordinary rapidity, and a rod of copper or iron $\frac{1}{4}$ inch in diameter is penetrated to the core in thirty minutes.

The ammonia is scarcely acted on in an ignited porcelain tube when clean and empty, but more readily when it contains fragments of porcelain (Gmelin).

T. M. L.

112. Theory of Solutions. W. Nernst. (Zeitschr. Phys. Chem. 88, pp. 497-500, Oct. 1, 1901.)—In this paper an attempt is made to develop a theory of solutions applicable to concentrated as well as dilute solutions. Briefly, the method is as follows: Consider the solution in equilibrium with a gaseous phase containing both the solvent and the solutes. Suppose for simplicity there are only three solutes, whose concentrations in the solution are c_1, c_2 , and c_3 , and whose partial pressures in the gaseous phase are Π_1, Π_2 , and Π_3 . Then, instead of the simple law $\Pi_1 = A_1 c_1$ where A_1 is a pure temperature function, Nernst writes $\Pi_1 = A_1 c_1 e^{a_{11}c_1 + a_{12}c_2 + a_{13}c_3}$ and corresponding expressions for Π_2 and Π_3 . The result of a certain isothermal and reversible

cycle is the equation $N \frac{dp}{p} + n_1 \frac{d\Pi_1}{\Pi_1} + n_2 \frac{d\Pi_2}{\Pi_2} + n_3 \frac{d\Pi_3}{\Pi_3} = 0$ where p = pressure of

solvent, $c_1 = \frac{n_1}{N}, c_2 = \frac{n_2}{N}, c_3 = \frac{n_3}{N}$. Substituting in this the values of Π_1, Π_2 , and

Π_3 assumed above, we get finally after integration—

$$\text{Log } \frac{p_0}{p} = c_1 + \frac{a_{11}}{2} c_1^2 + c_2 + \frac{a_{22}}{2} c_2^2 + c_3 + \frac{a_{33}}{2} c_3^2 + a_{12} c_1 c_2 + a_{23} c_2 c_3 + a_{13} c_1 c_3,$$

where p_0 = vapour pressure of pure solvent. This formula then leads at once to an expression for the osmotic pressure P of the solution, when combined with the equation—

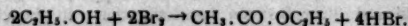
$$P = \frac{S}{M_0} RT \log \frac{p_0}{p},$$

where S = density of pure solvent, M_0 = molecular weight of pure solvent in state of vapour.

On this basis the whole theory can be easily built up. The various subjects considered are Lowering of Freezing-point, Law of Mass Action, Solubility, Electromotive Force, and Heat of Dilution. The paper concludes with polemical matter directed against Arrhenius.

F. G. D.

113. Velocity of Action of Bromine on Ethyl Alcohol. S. Bugarszky. (Zeitschr. Phys. Chem. 88, pp. 561-601, Oct. 18, 1901.)—When bromine is allowed to act on a large excess of 80 per cent. ethyl alcohol the action proceeds quantitatively and completely according to the scheme



Ethyl acetate and hydrogen bromide are the sole products, and no brominated substitution-products are formed. When only a small excess of the alcohol is used the reaction soon ceases, but can be carried through

completely by neutralising the hydrogen bromide at intervals with potassium hydroxide; in this case the bromine is converted quantitatively into potassium bromide. During the early stages the action proceeds as a reaction of the first order, but the velocity curve soon deviates from the typical form for a reaction of this type, showing that some disturbing influence has begun to operate. A trial experiment showed that this was due to the hydrogen bromide produced, and not to the ethyl acetate, which has no effect on the velocity; hydrogen bromide lessens the velocity of the action, and when it is present in excess the action proceeds throughout as a reaction of the first order. This result is explained by the supposition that the hydrogen bromide is capable of combining with the bromine and rendering it inactive, as represented by the equation $\text{Br}_2 + \text{HBr}_3 \rightleftharpoons \text{HBr}_3$. If c_1 be the concentration of the free bromine, c_2 that of the free HBr, and c_3 that of the combined bromine and hydrogen bromide (HBr_3), then by the law of mass action $c_1 c_2 = K c_3$, and the value assigned to this constant is $K = 0.00441$ at 25°C . The velocity of the interaction with the alcohol may be expressed by the equation $dc/dt = -kc_1$, where c is the concentration of the alcohol and c_1 that of the free bromine; if one minute is taken as the unit of time, then $k = 0.1052$. These two equations afford an accurate representation of the experimental facts, and when the interaction of the bromine with hydrogen bromide is allowed for, that of the bromine with alcohol is found to proceed quite normally.

T. M. L.

114. *Thermodynamics of Concentrated Solutions.* **A. Schükarew.** (Zeitschr. Phys. Chem. 88. pp. 548-560, Oct. 18, 1901.)—Employing Gibbs' method, the author obtains for the distribution of a solute between two immiscible solvents, at const. pressure and temp., the equation $(c - a)c'/(c' - a')c = \text{constant}$, where c and c' denote any two equilibrium-concentrations of the solute in the two phases, and a and a' the corresponding saturation-concentrations, i.e., the respective solubilities. This equation holds for all concentrations. The author tests the equation by means of Jakowkin's results for the distribution of iodine between water and carbon disulphide, and between chloroform and bromoform, and finds a satisfactory agreement. The equation may be also written $(c - c_0)c'/(c' - c'_0)c = \text{constant}$ where, as before, c and c' denote any pair of equilibrium-concentrations, while c_0 and c'_0 denote a certain particular pair, and are therefore constant parameters so far as the above equation is concerned. This form of the equation is tested for the cases of the distribution of iodine between CS_2 and aqueous solutions of KI, NaI, LiI and HI, and a moderately good agreement is found. Other cases of distribution give a similar result, e.g., the following distribution-equilibria, ether between water and rubber; β -naphthol between water and naphthalene; methylene green between water and silk.

The author then deals with velocity of solution and rate of diffusion, and finally applies Gibbs' equations to the case of the solubility of a salt in a solution containing another salt with a common ion.

For this case he arrives at the equation $(c_1 - c_{10})/(c_2 - c_3) = \text{constant}$, where c_{10} , c_2 are any two values for the solubility of the salt, the corresponding values for the concentration of the added salt being c_{10} and c_1 respectively. This equation is tested in the following cases: KBr, KNO_3 ; KBr, K_2CrO_4 ; KCl, K_2CrO_4 ; KCl, NH_4Cl ; KCl, NaCl; KNO_3 , $\text{K}_2\text{C}_2\text{O}_4$, $2\text{H}_2\text{O}$; KCl, KHCO_3 ; KBr, KNO_3 ; KCl, KNO_3 .

The agreement here is also of a fairly satisfactory nature.

F. G. D.

115. *Cryoscopic Experiments with Methylene Iodide.* **F. Garelli and V. Bassani.** (N. Cimento, 2. pp. 196-203, Sept., 1901.)—Methylene iodide is a difficult substance to use as a cryoscopic solvent, as it crystallises with extreme slowness, and concordant readings can only be obtained by taking many precautions. The readings made even with the solvent alone oscillate about two points, differing by about 0.4° , as if the liquid possesses two distinct freezing temperatures. From measurements with ethylene di-bromide, benzene and iodine, the molecular depression of the freezing-point of methylene iodide is found to be roughly 140. Stannic iodide, arsenic tri-iodide, and mercuric iodide have normal molecular weights in this solvent, and sulphur gives a value corresponding with the molecule S_8 . T. H. P.

116. *Internal Friction in Alcoholic Solutions of Salts.* **G. Haffner.** (Phys. Zeitschr. 2. pp. 739-742, Sept. 21, 1901.)—Nearly all the properties of solutions progressively rise or fall with increasing concentration. An exception, first noticed by Sprung (Diss. Leipzig, 1876), occurs in the internal friction of aqueous saline solutions, which first diminishes and then increases. For this relation Arrhenius's formula of 1887 has been repeatedly employed, and yields satisfactory results when the concentration is about $1\frac{1}{2}$ normal. The author now examines (1) whether Sprung's minima, especially shown by good conductors of electricity, are also exhibited with mixtures of alcohol and water, (2) whether Arrhenius's formula, viz., $\eta = A^x$, where η is the internal friction, x the concentration, and A a constant, holds good for alcoholic solutions of certain concentrations. After many trials, an apparatus, similar to Wiedemann's, with straight capillaries of circular section, was found best. Tables and curves are given of the results with ammonium chloride and nitrate, showing that dilute alcohol up to 22 per cent. behaves like water, but that with greater strengths, up to absolute, the phenomena are different. The conclusions are (1) that addition of a salt always raises the internal friction; (2) that this rise decreases with increasing concentration, giving curves concave to the x -axis; whence it follows that Arrhenius's formula, $\eta = A^x$, always positive, is not applicable, as it gives a curve which is convex to the x -axis; (3) consequently also no Sprung's minima, but, on the other hand, maxima are developed; (4) the influence of these salts declines with rising temperature, as it does when non-electrolytes are added to water (Arrhenius, 1887); the curves (isotherms) diverge also in this case. S. R.

117. *Chemical Pseudo-Equilibria and Explosive Systems.* **L. Marchis.** (Journ. de Physique, 10. pp. 525-542, Sept., 1901.)—This is a continuation of a previous paper on the same subject [see Abstract No. 2061 (1900)]. The paper, according to a footnote of the author, does not contain any new facts or theories, but is simply an exposition in "ordinary language" of Duhem's theory, as set forth in the latter's Treatise on Chemical Mechanics, pp. 246-289. The subject treated of in this communication is the application of the theory of pseudo-equilibria to the conditions which determine the stability or instability of chemical systems; in particular, the conditions which determine the explosion of a gaseous system. It contains, therefore, an outline of Duhem's theory of explosions, and will be of value to those interested in explosives, as giving a concise and clear account of modern theoretical advances in this subject. F. G. D.

118. *Temperature Limits for the Separation of Graphite from Martensite in Pure Cast Iron.* **H. P. Tiemann.** (Metallographist, 4. pp. 818-832,

Oct., 1901.)—Attention is called to the enormous influence of silicon in determining the separation of graphite from cast iron. It is somewhat difficult to secure the absence of this impurity from iron, and a large number of the recorded experiments are of little value, owing to this important factor having been overlooked. Experiments are now described which were made with a sample of iron containing no silicon, 0.081 per cent. P, 0.002 per cent. S, 0.040 per cent. Mn, and 0.080 per cent. combined carbon; this was carburised with sugar-charcoal in crucibles, free from silica, until it contained 4.271 per cent. combined carbon and 0.255 per cent. graphite. It was found that the proportion of graphite was quite unchanged by heating up to temperatures as high as $1,116^{\circ}\text{C}$., and then quenching in iced brine at -5°C .; when heated to $1,800^{\circ}$, and allowed to cool to $1,040^{\circ}$ before quenching, the proportion of graphite was raised to 0.677 per cent.

According to Roozeboom's diagram, cementite (combined carbon) should be entirely converted into graphite at any temperature above $1,000^{\circ}$. The results here described go to show that this change does not readily take place in a pure cast iron unless the temperature is raised far above the "transition-point." On the other hand, an iron containing 0.75 per cent. Si, 8.438 per cent. combined carbon, and 0.938 per cent. graphite, was found to contain 2.795 per cent. graphite when heated to $1,125^{\circ}$ and quenched at -5° , and the proportion of graphite was increased to 1.690 per cent. when the iron was heated only to 975° , a temperature 25° below the transition-point; this shows that the silicon not only facilitates the formation of graphite above the transition-point, but also lowers the transition-point, so that the formation of graphite may take place below $1,000^{\circ}\text{C}$.

T. M. L.

119. *Periodic Electric Phenomena in the Solution of Chromium in Acids.* E. Brauer. (Zeitschr. Phys. Chem. 38, pp. 441–486, Oct. 1, 1901.)—Further particulars are given of Ostwald's researches [see Abstract No. 163 (1901)] which the author is continuing. Two types of recording instruments are described. The one registers photographically both the gas pressure of the hydrogen, evolved during the solution of chromium in the hydrochloric acid, and the current intensity; in the other a syphon traces the current curve only. The two curves are perfectly parallel, and analogous to one another; the pressure curve fluctuations lag a little behind the current fluctuations, however, and are not quite so sensitive. A very pure chromium displayed no periodic phenomena, which appeared when arsenic or sulphur were added to the acid. These two elements were found in most of the chromium specimens experimented with, but the so-called "oscillating" chromium (exhibiting periodic phenomena) is more pure in this respect than the non-oscillating metal. General conclusions cannot yet be drawn.

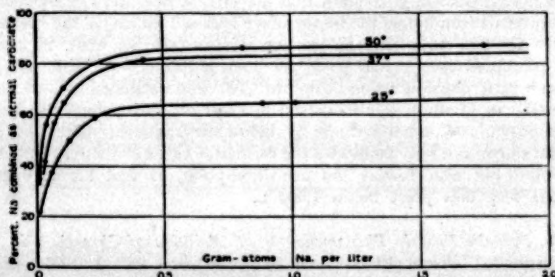
H. B.

120. *Inversion-points of Dilutions.* A. Colson. (Comptes Rendus, 133, pp. 585–587, Oct. 14, 1901.)—Berthelot has shown that in the case of some salts there is a temperature at which the heat of solution changes sign. The author finds that the heat of solution of 25 grm. NaCl in a litre of water is zero at 70° , and that of 75 grm. in a litre is zero at 75° . The heats of solution become identical at 52° , i.e., the heat absorption is the same when 75 grm. NaCl is dissolved in 1 litre or in 8 litres of water; from this it follows that the heat of dilution is zero at 52° , and changes sign at this temperature, being positive at higher and negative at lower temperatures. The inversion-point of sodium chloride is raised by the addition of hydrochloric acid or caustic soda; in presence of 1 molecule of HCl per litre the inversion-point

is 88° , and in presence of 2 molecules per litre 100° ; in presence of 1 molecule of NaOH per litre the inversion-point is 80° , and in presence of 2 molecules per litre 100.8° ; the acid and alkali thus produce almost identical effects.

T. M. L.

121. Equilibrium between Carbonates and Bicarbonates in Aqueous Solution. F. K. Cameron and L. J. Briggs. (Journ. Phys. Chem. 5, pp. 537-555, Nov., 1901. Contribution from the Bureau of Soils, U.S. Dept. of Agriculture.)—The discovery, in the author's laboratory, that both carbonates and bicarbonates can be readily estimated when present together in the same solution, by adding phenol phthalein, running in standard potassium hydrogen sulphate until the pink colour due to the indicator disappears, then adding methyl orange, and continuing the titration until neutrality has been obtained, has enabled the authors to investigate the distribution of the base between carbonic and bicarbonic acids, in the case of sodium, potassium, and



magnesium carbonates in solutions which are in equilibrium in contact with air.

For the experiments, the solutions to be examined were arranged in flasks placed in a water-bath and connected together by a system of stoppers and tubing. Air was aspirated through the flasks until equilibrium was established; the contents of the flasks were then titrated. The accompanying diagram gives the results for sodium carbonate; the other substances give similar results.

D. H. J.

122. Alkali Salts of Hydroperoxide in Aqueous Solution. H. T. Calvert. (Zeitschr. Phys. Chem. 88, pp. 513-542, Oct. 18, 1901.)—The fact that hydroperoxide, a name suggested by v. Baeyer for hydrogen peroxide, exhibits acid functions, has been shown by several physico-chemical methods. With the alkali hydroxides, hydroperoxide forms salts which are appreciably hydrolysed in solution; the amount of hydrolysis can be diminished by the presence of excess of hydroperoxide, owing to the formation of acid salts of the type MO_2 . The proportion of hydroperoxide which can be removed from solution in an alkali by shaking up with amyl alcohol is less than that removed from aqueous solutions; the results of experiments show that one equivalent of alkali combines with 1.5 molecule of hydroperoxide. The acid alkali salts MO_2 of hydroperoxide form monovalent oxygen ions of the composition O_2^- , which ions in some cases undergo hydration. The velocity of this ion has a mean value of 48.5. The conductivity of alkali salt solutions is lowered by the addition of hydroperoxide, but not to a greater extent than by non-electrolytes,

so that no formation of a complex ion containing an alkali metal takes place. The solubility of potassium chlorate in hydroperoxide solution is considerably greater than in water. Freezing-point measurements of solutions of salts, the extent of hydrolysis of which has been depressed by addition of excess of alkali, indicate the existence of divalent ions of the composition O_2^{2-} , but no confirmation has as yet been obtained of this.

T. H. P.

123. Solubility of Gypsum in Aqueous Solutions of Sodium Chloride at Different Temperatures. **F. K. Cameron.** (Journ. Phys. Chem. 5, pp. 558-576, Nov., 1901. Contribution from the Bureau of Soils, U.S. Dept. of Agriculture.)—Below $37^{\circ}5$ C. the experimental results show a maximum solubility point. Above this temperature the existence of such a point is doubtful. A condensation of the water as solvent takes place when gypsum and sodium chloride are brought into solution.

D. H. J.

124. Physical Properties of Nitric Acid Solutions. **V. H. Veley and J. J. Manley.** (Roy. Soc., Proc. 69, pp. 86-119, Nov. 19, 1901.)—The densities of mixtures of pure nitric acid and water were determined at 4° , at 14.2° and at 24.2° , and curves were plotted showing the contraction in the formation of 1 gm. of the solution. These curves could be represented by a series of straight lines, the intersections being replaced on the experimental curves by continuous lines; the chief intersections were at about 20, 33, 42, 54 (max. contraction), 63, 70, and 78 %, corresponding to the hydrates $HNO_3 \cdot 14H_2O$ (20.31 %), $HNO_3 \cdot 7H_2O$ (33.33 %), $HNO_3 \cdot 4H_2O$ (41.18 %), $HNO_3 \cdot 3H_2O$ (53.98 %), $HNO_3 \cdot 2H_2O$ (63.63 %), $2HNO_3 \cdot 3H_2O$ (70 %), and $HNO_3 \cdot H_2O$ (77.77 %).

A refractive index curve, plotted in a similar way, gave intersections at 20, 33, 40, and 70 % maximum refraction, corresponding with the hydrates containing 14, 7, 4, and 1.5 molecules of water respectively.

T. M. L.

125. Proof of Formula for Lowering of Freezing-point of Solutions. **F. Lengfeld.** (Journ. Phys. Chem. 5, pp. 499-501, Oct., 1901.)—A proof of van't Hoff's formula, $dT = 0.02T^2/L$, for the lowering of the freezing-point of a solution is derived from the consideration of a solution, in a cylinder with a semi-permeable end and a movable piston, being submitted to the following cycle of changes. A quantity of the solvent is frozen out at the freezing-point of the solution and separated from the solution. The temperature of the whole is raised to the melting-point of the solvent and the solvent allowed to melt. The liquid solvent is brought into contact with the solution at the semi-permeable membrane, the pressure being equal to the osmotic pressure, and by raising the piston under this constant pressure the solvent passes through the diaphragm. Finally the whole is brought back to the original temperature.

W. E. T.

126. Velocity of Decomposition of Ammonium Nitrite. **K. Arndt.** (Zeitschr. Phys. Chem. 39, pp. 64-90, Nov. 12, 1901.)—The author describes a number of experiments on the decomposition of ammonium nitrite under various conditions, and from his results draws the following conclusions. The reaction consists in a decomposition, under the influence of free nitrous acid, of the non-dissociated portion of the ammonium nitrite into nitrogen and water. A rise of temperature of 10° (60° - 70°) causes a threefold increase in the velocity of decomposition. The addition of ammonium sulphate also increases the

velocity of the reaction owing to a depression of the dissociation of the ammonium nitrite. Sodium nitrite has a similar action, since it both lowers the amount of dissociated ammonium nitrite and increases the concentration of the free nitrous acid. All salts containing neither NH_4 or NO , diminish the velocity of the reaction, potassium salts having a greater effect than those of sodium, whilst magnesium salts have a still slighter action; sulphates cause a greater diminution than nitrates or chlorides. This lowering of the velocity of decomposition depends on the diminution of concentration of the ammonium nitrite and also of that of the free nitrous acid due to the difference of the degree of hydrolytic dissociation. Very small proportions of ammonia bring about very considerable diminution in the velocity of the reaction, which is greatly accelerated by small quantities of acid. From the magnitudes of these influences, it follows that in a 0.6 normal aqueous solution, ammonium nitrite is resolved into free acid and base to the extent of about 0.5 per cent. at 75° and 0.25 per cent. at 70° . T. H. P.

127. *Constitution of Inorganic Compounds.* A. Werner and C. Herty. (Zeitschr. Phys. Chem. 88. pp. 331-352, Sept. 17, 1901.)—The author first discusses the objections raised by Petersen to his method of determining the type of a salt by means of the molecular conductivity at a certain dilution, and then goes on to show that the order of magnitude of the conductivity gives a certain indication as to whether a salt splits up into two or three or more ions. The authors' experiments show that by the replacement of two molecules of ammonia in the complex cobalt compounds by ethylenediamine, the molecular conductivity is lowered. Measurements of the conductivity of and of the depression of the freezing-point by 1:6- and 1:2-dichlorodiethylenediaminecobalt chlorides and nitrates, which in aqueous solution undergo gradual hydrolysis and are changed from two-ion into three-ion salts, show that at 0° and at 25° these salts in water form two ions. Results are given of the measurement of conductivity of several other cobalt-ammonia and platinum-ammonia compounds. T. H. P.

128. *Dissociation Relations of Ternary Electrolytes.* K. Drucker. (Zeitschr. Phys. Chem. 88. pp. 602-608, Oct. 18, 1901.)—Assuming the validity of the law of mass action, the author obtains equations which can be applied to experimental results for the purpose of ascertaining the complex ions existing in solutions and for determining the concentration of the ions of a mono- and di-valent salt. If a salt of the type AB_2 forms no complex ions AB , A can be directly calculated from the difference of the values of the total concentration obtained from osmotic measurements and those arrived at analytically. From his experimental numbers, the author concludes that sulphuric acid is dissociated directly into SO_4 and H ions, and forms no ions of the form HSO_4 . T. H. P.

129. *Dissociative Power of Different Solvents.* H. C. Jones. (Chem. News, 84. pp. 95-98, Aug. 23; 106-108, Aug. 30; 135-136, Sept. 13; p. 146, Sept. 20; and pp. 159-160, Sept. 27, 1901. From the Amer. Chem. Journ. 25. No. 8.)—The author gives a summary of all the work published on the dissociative power of solvents, the latter being divided under the following heads. *Inorganic solvents*: Including water, ammonia, nitric acid, sulphur dioxide, sulphur dichloride, sulphuryl chloride, thionyl chloride, phosphorus oxychloride, arsenic and antimony trichlorides, halides of boron, phosphorus, silicon and tin, and sulphur trioxide and bromine. *Organic solvents*: Methyl,

ethyl, propyl, isopropyl, allyl, isobutyl and isoamyl alcohols, ether, ketones, formic and acetic acids, the nitriles, pyridine, ethyl sulphide, glycerin, benzene, xylene, hexane, benzene chloride, ethyl iodide and bromide, amyl acetate, acetophenone, ethyl acetate and acetoacetate, benzaldehyde and nitrobenzene. *Mixed solvents*: Hydrogen dioxide and water; alcohols and water.

An examination of the work reviewed shows that different solvents have very different ionising powers; with the possible exception of hydrogen dioxide, water is the strongest ioniser, formic acid coming next. Methyl alcohol dissociates to a much greater degree than ethyl alcohol, and in general the lower members of a homologous series of solvents have the greater dissociative power. A high dissociating power is, as a rule, accompanied by a high dielectric constant, but the two constants are not proportional to one another. Dutoit and Aston's suggestion that there is some connection between the amount of association of the molecules of a solvent and its power to ionise electrolytes is doubtless true; thus, for example, the molecule of liquid water at ordinary temperatures is $(H_2O)_n$, while the alcohols and other strongly dissociating solvents show considerable association of their molecules. It is probable, however, that the dissociative power of a solvent depends on all its physical and chemical properties. The most important conclusion to be drawn from the work here reviewed is that ions are almost always present when chemical reaction takes place, and by preventing the formation of ions chemical action may be stopped. Thus a chloroform solution of dry hydrogen chloride will not decompose carbonates, while dry ammonia and hydrogen chloride do not react, and dry liquid hydrogen chloride does not act on litmus. All the evidence goes to show that only ions are capable of taking part in chemical actions.

T. H. P.

130. *Contact E.M.F.'s and the Ionic Theory.* E. Rothé. (Journ. de Physique, 10. pp. 546-555, Sept., 1901.)—This is a full account of experiments, a note on which has already appeared in the Comptes Rendus [see Abstract No. 1970 (1901)]. The line of argument is as follows:—Consider the e.m.f. of a concentration cell, the electrodes being mercury, and the solutions being saturated with respect to mercurous sulphate or chloride, but containing different amounts of sulphuric or hydrochloric acid respectively. Denoting by $Hg | L$ the p.d. at a metal-liquid junction, and neglecting the small p.d. at the liquid-liquid junction we have according to the ionic theory $Hg | L_1 - Hg | L_2 = \frac{RT}{n\epsilon} \log \frac{p_2}{p_1}$ using the ordinary notation. Putting $\frac{p_2}{p_1} = \frac{c_2}{c_1}$, when c_2 and c_1 are the concentrations of the mercurous ions, and taking into account the small solubility of the mercurous salts even in their saturated solutions, it follows from the law of mass action that $\frac{c_2}{c_1} = \frac{c'_2}{c'_1}$, where c'_1 and c'_2 are the concentrations of the SO_4 or Cl ions. And, very approximately, $\frac{c'_2}{c'_1} = \frac{a_1 C_1}{a_2 C_2}$, where C_1 and C_2 are the acid concentrations, and a_1 a_2 the corresponding degrees of ionisation. Thus we get—

$$Hg | L_1 - Hg | L_2 = \frac{RT}{n\epsilon} \log \frac{C_1 a_1}{C_2 a_2}$$

Accordingly, any one of a series of values of the single p.d., $Hg | L$, can be calculated from any other, since the value of the right-hand member of the

above equation can be calculated from known data on the conductivity of solutions of sulphuric and hydrochloric acids. The author obtains this series of values of the single p.d. $\text{Hg} \mid \text{L}$ by using the above solutions in turn in a Lippmann electrometer, bringing the surface tension to its maximum value by a compensating p.d., and assuming then in the well-known way that the p.d. at the capillary electrode is zero, so that the value of the compensating p.d. gives the value of $\text{Hg} \mid \text{L}$ at the large mercury electrode in each particular case. Taking now $\text{Hg} \mid \text{L}$ for the sulphuric acid solution of density 1.0337 equal to 0.892 volt, and $\text{Hg} \mid \text{L}$ for the hydrochloric acid solution of density 1.017 equal to 0.568 volt, the following results are obtained :—

1. SULPHURIC ACID SOLUTIONS.

Density.	P.D. (volts.)	
	Observed.	Calculated.
1.0083	0.87	0.885
1.0062	0.875	0.873
1.0167	0.883	0.884
1.03107	0.890	0.891
1.0337	0.892	(0.892)
1.0340	0.894	0.8945
1.0682	0.910	0.901
1.1048	0.925	0.903

2. HYDROCHLORIC ACID SOLUTIONS.

Density.	P.D. (volts.)	
	Observed.	Calculated.
1.0010	0.554	0.542
1.0081	0.560	0.5605
1.017	0.568	(0.568)
1.0242	0.576	0.522
1.0490	0.600	0.578

The agreement is found to be very good, except in the stronger solutions.

F. G. D.

131. *Heats of Dissociation and Combustion of Acetylene, Ethylene, and Methane.* **W. G. Mixter.** (Amer. Journ. Sci. 12. pp. 347-357, Nov., 1901.)—The method used by the author for the determination of the heat of dissociation of acetylene is the direct measurement of the heat evolved when the gas is exploded in a calorimetric bomb; in the cases of ethylene and methane, sufficient acetylene is added to yield a mixture which explodes, the heat developed being determined as before. The following table contains the author's results, the numbers representing calories per gram-molecule of each gas; 1 and 12 are taken as the atomic weights of hydrogen and carbon respectively.

	Heat of Formation.	Heat of Combustion.
Acetylene	— 53,300	313,800
Ethylene	— 10,600	345,800
Methane	+ 18,420	—

The above values were obtained at constant pressure. The determinations of other authors are referred to.

T. H. P.

132. *Tri-iodides*. **Y. Osaka**. (Zeitschr. Phys. Chem. 88: pp. 743-749, Nov. 1, 1901.)—The author gives results of measurements of the freezing-points of solutions of potassium iodide and hydrogen iodide of different concentrations, before and after the addition of iodine, which causes an elevation of the freezing-point. The differences are, however, independent of the concentration of the iodide, but are proportional to the concentration of the added iodine. In the case of the hydriodic acid, the molecular elevation of the freezing-point is greater than with potassium iodide, and the thermal dissociation constant for hydrogen tri-iodide is perhaps somewhat greater than that of potassium tri-iodide. These results are discussed in relation to those of other investigators, from which they differ. T. H. P.

133. *Polarisation of Aluminium*. **A. Naccari**. (Accad. Sci. Torino, Atti, 36. 12a. pp. 469-481, 1901.)—The author measures separately the polarisation shown by aluminium when used as anode and kathode respectively. The aluminium plate which is to form the electrode is placed in a vessel containing dilute sulphuric acid. The vessel is joined by means of three wide glass siphons with another containing the same liquid and an aluminium electrode. The first vessel is also joined by means of a siphon with another which contains the same liquid and a plate of aluminium. The latter is at a certain moment connected with an electrometer for measuring the potential of the liquid in which the aluminium electrode is immersed, while the electrode itself is connected to earth. The experiments show that the polarisation gradually increases, reaching a maximum of 10 volts in about eight minutes, and then decreasing to about half that amount in about half an hour, after which it remains steadily at that amount. This, however, only applies to fresh plates, for on repeating the experiment with the same plate the next day, the final value of the polarisation is reached almost at once. The author inclines to the opinion that the resistance created by a thin coating of aluminium oxide is the determining factor in the phenomena described. This view is supported by the fact that the polarisation diminishes on increasing the concentration of the sulphuric acid, which would facilitate the solution of the oxide or hydrate. E. E. F.

134. *Standard Cells*. **H. Rupp**. (Elektrotechn. Zeitschr. 22. pp. 544-546; 564-565; and pp. 585-588, 1901.)—The e.m.f. of Clark cells was found by Cooper to depend, not merely on the temperature, but also on the rate of change of temperature—that is to say, if the cell be kept at a constant temperature for a time sufficient to enable the whole cell to reach this temperature, the e.m.f. will still depend on the previous temperature. This is probably due to very slow diffusion and concentration phenomena. The author made experiments to determine to what extent the e.m.f. depended on the previous history of the cell. The temperature was varied, and the e.m.f. both measured and reckoned from Jaeger and Kahle's formula. The cell before experiment had been kept for 75 hours at a temperature of 18°; it was then raised to 21°, and measurements commenced after twenty-four hours. The temperature was gradually increased to 28° during two days, and throughout this time the measured e.m.f. was higher than the calculated by amounts increasing from 0.00085 to 0.00054 volt. These differences the author attributes to the cell having been kept at the lower temperature of 18°. The cell was then kept at 25°-26° for three days, and again lowered to 28°, when the observed and calculated e.m.f. were practically equal, showing the after-effect of the

higher temperature. Lowering the temperature to 14°, made the observed value smaller than the calculated by 0.00028 volt, even after nine days.

In the Cadmium cell these variations are absent, as the cell has only a negligible temperature coefficient. A comparison was made between two cells, one prepared at the Physikalische Technische Reichsanstalt, the other by the Weston Instrument Company. At 10° C. their e.m.f.'s were 1.01925 and 1.01905 respectively, and at 80° 1.01855 and 1.01915.

Further experiments were made on the behaviour of cells when giving current. The resistance of Clark cells was found to vary considerably with the temperature, with the time during which current was taken, and, to a small degree, with the current. The following figures were obtained from a Clark cell, the current being expressed in micro-amperes, and the measurements being made after four minutes' duration of current:—

Temperature.	Current.	Resistance.
13.10°	2.43	234.7
	14.83	217.5
	141.02	177.8
17.55	2.42	198.3
	14.29	195.7
	141.13	142.3
21.00	2.41	206.8
	14.26	128.1
29.21	2.39	125.8
	14.16	95.2
	140.50	80.4

The effect of duration of current was to diminish the resistance. With 14.8 micro-amperes the resistance was, after 75 secs., 160.8; after three minutes, 149.6; after eleven minutes, 145.4. The Cadmium cells showed a similar behaviour; that prepared by the Reichsanstalt had a high internal resistance of about 2,000 ohms, which varied but little with the current, but which diminished considerably with increase of temperature. The Weston cell showed a small decrease with increase of temperature, but a considerable rise with increase of current; its internal resistance was only about 150 ohms.

The author next determined the variation of potential difference with the current. In the Clark cell the potential difference diminished steadily when small currents were taken; with larger currents it diminished at first and then increased. It was from 1 to 2 per cent. less than the e.m.f. when the cell was closed on 10,000 ohms, the exact value depending on the temperature. The variations with temperature and time are so great as to render the cell useless for measurement except in zero methods. The Cadmium cell is better in this respect, as the variation of the potential difference with time is very small. The author found that it could be expressed by the formula $V = a - bC$, where c is the current, and a and b constants for any one temperature, or, introducing the outside resistance R , by the formula—

$$V = \frac{R(a + \beta I)}{R + \alpha_0 + \beta_0 I + \gamma_0 I^2}$$

This formula, with values for the constants reckoned from one Cadmium cell, was found applicable to the two other cells under measurement to within 0.1 per cent.

Finally, the author observed the time of recovery of e.m.f. after the cell had given current. The Clark cell, after giving 8.7 micro-amperes

for 45 seconds, had an e.m.f. lower by 0.0004 volt, which rose to the normal only after 6 minutes rest. After giving the same current for six minutes the drop was 0.0006 volt, and after 20 minutes' rest was still 0.0002 volt. The Cadmium cell was far better in this respect; after giving 100 micro-amperes for 5 minutes, it recovered its normal e.m.f. in $2\frac{1}{2}$ minutes. After giving this current for nine days, however, the e.m.f. was permanently diminished by 0.0007 volt.

G. H. B.

135. Magnesium in Electrolytic Rectifiers. A. Campetti. (Accad. Sci. Torino, Atti, 86, 7a. pp. 251-256, 1901.)—When a current is passed through a voltameter containing caustic potash or soda, from an anode of magnesium to a kathode of platinum, there is a marked diminution in the strength of the current, which is not due entirely to the opposing e.m.f. of polarisation, but mainly, in the author's opinion, to the formation of a thin badly conducting layer of oxide on the surface of the magnesium. The phenomena are similar to those observed in the case of aluminium, and the cell, when inserted into an alternating-current circuit, acts as an electrolytic valve. With voltages varying from 18 to 60, and with a frequency of 15, calorimetric measurements show that under the most favourable conditions the loss in the cell does not exceed from 10 to 15 per cent. of the energy developed.

D. H. J.

136. Polarisation and Internal Resistance of Electrolytic Cells. M. D. Atkins. (Phys. Rev. 13. pp. 102-124, Aug., and pp. 182-192, Sept., 1901.)—Electrodes of copper in CuSO_4 , and zinc (amalgamated, either plates or liquid amalgam) in ZnSO_4 , when freshly placed in their respective solutions, give, with varying currents, curves completely satisfied by a formula of the Bartoli-Wiedeburg form (Wiedeburg, Habilitationsschrift Leipzig, 1893; Wied. Ann. 51, 802, 1894; Guthe and Atkins, Proc. A.A.A.S., 1899, p. 109; Guthe, Phys. Rev. 7, p. 38; Wiedeburg, Zeit. Phys. Chem. xiv., 1, 1894), and its derived equations. With such electrodes the internal resistance is therefore constant. Electrodes of silver in AgNO_3 and zinc in ZnSO_4 in the main give curves satisfied by such a formula; but electrodes of platinum (polished) in H_2SO_4 do not. The maximum value for the polarisation of Pt in H_2SO_4 is, however, in agreement with that found by other methods. Electrodes of all these metals in their respective solutions show, upon standing, a marked increase in apparent resistance; all results obtained concur in their testimony that this is not an increase in the real resistance of the coil. Neither the inverse proportionality of the constant K [K being a constant, defined by the equation $p = P(1 - e^{-Kt})$ where p and P are the momentary and maximum polarisations respectively, while t is the time; also $K = \beta I/S$ where β is a constant depending on the electrodes, I is the current, and S is the area of the electrodes] to the area of the electrodes nor its direct proportionality to the time of flow of current is conclusively established. While the theory of Wiedeburg is therefore not sustained as to its constants, an equation of the same general form would seem to be suggested. The method of the research is based on the Bartoli-Wiedeburg formula, where the polarisation-capacity is $c' = e^{at}/Pa$ (where a is a constant depending on the size of the electrode) and the initial capacity is $c = t/PK$; whence the constant current method employed. It is found capable of giving the internal resistance within 1 per cent., the maximum value of P , and the polarisation capacity even when this is very large.

A. D.

137. *Constitution of Complex Salts according to Electrolytic Behaviour.* **E. Rieger.** (Zeitschr. Elektrochem. 7. pp. 868-868, Aug. 29, and pp. 871-876, Sept. 5, 1901. Also Zeitschr. Anorg. Chem. 25. p. 180, 1900.)—The determination of migration constants, as was shown by Hittorf, throws light on the chemical constitution of complex salts. The author has examined the behaviour on electrolysis of a number of salts, and finds that in potassium copper sulphate, potassium silver iodide, potassium mercury iodide, potassium mercury cyanide, potassium zinc cyanide, potassium cadmium cyanide, potassium ferrous oxalate, and potassium ferric oxalate, the nobler metal travels to the anode, thus indicating the existence of an anionic complex. This conclusion is confirmed by the diminished conductivity of the salt solutions, as compared with the conductivity calculated from that of the components of the complex salt. N. L.

138. *Electrolytic Transport Values and E.M.F. of Reversible Elements.* **R. Gans.** (Ann. d. Physik, 6. 2. pp. 815-830, Oct., 1901.)—The theoretical part of this paper consists of the deduction from thermodynamic principles of various equations showing how the dependence of electrolytic transport values on physical parameters may be ascertained from that of e.m.f. on those parameters. In particular, the author considers the influences of pressure and temperature, pointing out that all relations deduced under the assumption of constant transport values require extension, and determining

$$E - T \frac{dE}{dT} - ET \frac{d \log k}{dT} = Q$$

as the extended form of Helmholtz's equation, in which $k = de/ds$, e is the quantity of electricity sent through, and s is the amount of salt measured in gram-equivalents. Experiments for zinc sulphate lead to the equation $E = 0.01644 (1 + 0.000184p)$ for the e.m.f. in volts, p being the increase of pressure in atmospheres; from this is deduced for the transport value of the kation, the equation $1 - n = 0.699(1 + 0.00012p)$. W. E. T.

139. *A Voltametric Balance.* **W. Pfanhauser, Jr.** (Zeitschr. Elektrochem. 7. pp. 923-924, Oct. 10, 1901.)—This apparatus, which forms the subject of a German patent, consists of a copper voltameter containing a solution of sp. gr. 1.2, and the kathode of which is suspended from one arm of a balance-beam. The other arm of the balance-beam is provided with a scale-pan in the usual way, and weights are added until the kathode is exactly counterbalanced in its normal position, i.e., whilst partly immersed in the electrolyte. When this is so, the kathode-arm of the balance-beam rests on a contact-piece, or stop, insulated from the rest of the frame of the balance, and thus completes the circuit of an electric bell. The scale-pan arm of the balance-beam carries an adjustable contact-piece, which, when the kathode is counterbalanced as above mentioned, is just out of contact with the mercury in a cup, this contact-piece and the mercury being arranged in the main circuit, i.e., in series with the kathode and a plating bath in which a definite amount of, e.g. silver, is to be deposited. Weights are then placed in the scale-pan equal to the weight of copper, equivalent to the amount of silver to be deposited, less the loss of weight due to the copper being immersed in the electrolyte in the voltameter. This causes the balance-beam to tilt so as to break the bell-circuit and close the main-circuit. When the predetermined amount of metal has been deposited, the balance-beam tilts

back again, breaks the main-circuit, and closes the bell-circuit, thus giving notice to the attendant. The following table is also given :—

When <i>g</i> grammes of silver to be deposited.	Weight in grammes to be placed in the scale-pan after counter-balancing.
1	0.262
2	0.524
3	0.786
4	1.048
5	1.309
10	2.619
20	5.228
30	7.856
40	10.477
50	13.098
100	26.186

C. K. F.

140. *Electrolytic Production of Alkali and Chlorine.* A. Cohn and E. Geisenberger. (Elektrochem. Zeitschr. 8. pp. 128-130, Sept., 1901.)—The authors claim to have overcome the two chief defects of the methods now in use, viz., the want of durability of the diaphragms, and the waste of carbon, due to formation of hypochlorite at the anode. The principle of their own method is the use of a temperature so low, that the sodium hydrate separates at the kathode in the solid state.

Two forms of apparatus are described for carrying out their process. The first consists of a cylinder mounted on hollow trunnions and rotating in a vat containing the freezing solution. The cylinder is three-parts filled with the electrolyte, and in its lower part carbon anodes are placed, these being carried on fixed supports. The current passes between these anodes and the wall of the cylinder which acts as kathode. The sodium hydrate separates in the solid state on the wall, and is carried by the rotation of the cylinder up to a fixed scraper, which detaches the hydrate, and causes it to fall into a fixed collecting vessel, from which it is continually removed. The chlorine gas liberated at the anodes is collected by a fixed hood, and passes away from the vessel by the hollow trunnions. A second form of electrolyser consists of a series of inverted funnels arranged one above the other in a suitable containing vessel. The anodes and kathodes are fixed upon the opposite sides of the funnel walls. The space between two successive funnel walls thus acts as a separate cell.

An electrolyte at 22° B., and a temperature of — 30 to — 88° C. are recommended by the authors. J. B. C. K.

141. *A New Form of Platinum Electrode.* (Electrician, 47. p. 911, Oct. 4, 1901.)—This is designed for competing with platinum in durability and with ordinary carbon electrodes in cheapness, and consists of a thin glass tube, closed at the lower end by fusion, into the walls of which a number of fine platinum wires are fused, to the projecting ends of which strips of platinum-foil 0.8 inch wide and only 0.0008 inch in thickness are attached by autogenous soldering. The connection with the current supply is provided by an equal number of copper strips, which pass down the interior of the tube, and are soldered to the portions of the platinum wires which pass through it. The

upper ends of these wires are soldered to a copper block, to which the electrical connection is made. An electrode constructed in this way, with an active surface of 10.75 square feet, will only require 100 grms. of platinum. The loss of e.m.f. by internal resistance can be reduced to a minimum by using sufficiently thick copper wires to make the connections in the interior of the tube, and by increasing the thickness of these wires the electrode can be used for high current densities. The inventor considers that it will now be possible to use platinum as the electrode material in many electrolytic processes, &c., from which its high price has hitherto excluded it, and that in this new form platinum can even compete in price with carbon. J. L. F. V.

142. *Acker Process for the Electrolytic Production of Alkalies and Chlorine.* J. B. C. Kershaw. (Electrician, 48. pp. 20-21, Oct. 25, 1901.) (See also Elektrochem. Zeitschr. 8. pp. 142-148, Oct., 1901.)—This process has for its object the production of chlorine and caustic alkalies from fused chlorides by electrolysis, employing a kathode of fused lead for the absorption of the sodium liberated, forming the subject of a series of patents held by the

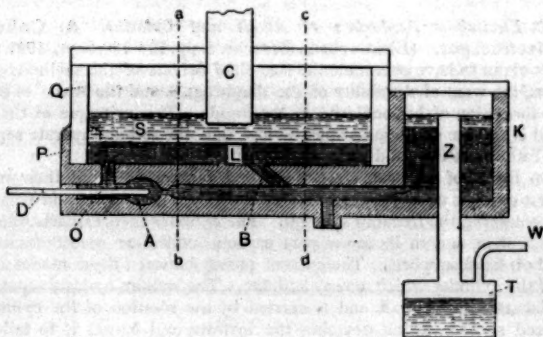


FIG. 1.



FIG. 2.

FIG. 3.

Acker Process Company at Niagara Falls. Previous attempts by Vautin and Hulin are mentioned. The principle and action of the cell is best explained by referring to the diagram, Fig. 1.

P is the bottom of the cell, trough-shaped and made of cast iron. It serves as electrical connection between the main conductor and the fused lead resting upon it. The upper portion Q is constructed of refractory material not attacked by chlorine and fused salt, and fits closely into the cast-iron trough. S is the layer of fused salt, and C the carbon anode dipping into it.

The main feature of the cell is the circulation of molten lead-sodium alloy, as indicated by the arrows in the diagram. This is effected by a system of channels, which will be clear from diagrammatic cross-sections through AB and CD (Figs. 2 and 3).

A pipe D, ending in an egg-shaped enlargement at the point A in Fig. 1, supplies steam under pressure, and thus causes circulation of lead-sodium alloy from the cell into the closed chamber K. NaOH and H are here formed, and the molten caustic passes through Z into the collecting vessel. The lead freed from sodium collects in the lower part of K, and continually flows back, through side channels and the opening B, into the bottom of the decomposer, thus acting continuously as a carrier for the Na.

A modification of this apparatus is also explained. The author states that anhydrous caustic soda, 79 per cent., Liverpool test, can be produced by the Acker process, and does not quite agree with the adverse criticism which recently appeared in the *Zeitschr. Elektrochem.* (*loc. cit.*), although he thinks it wiser to assume that the process is still in the experimental stage of development.

O. J. S.

143. Distribution of Lines of Current in Electrolytes. W. Pfanhäuser, Jr. (*Zeitschr. Elektrochem.* 7. pp. 895-897, Sept. 26, 1901.)—The causes of uneven deposits in electroplating form the gist of this paper. Particular attention is drawn to the thickening of deposits at the edges, and also to the plating of complicated objects and those which have large cavities which require to be coppered or brassed. In such cases auxiliary anodes are required, or special rheostats must be employed for the purpose of adjusting current densities. Formulæ for the distribution of the current lines are also given. Special reference is made to the difficulties in depositing brass, and the necessity of having sodium bisulphite present, in the case of cyanide baths for this purpose.

O. J. S.

144. New Form of Electric Furnace. C. Keller. (*Elektrochem. Zeitschr.* 8. pp. 156-159, Oct., 1901.)—This furnace differs from other types in the fact that the electrodes form the hearth and sides of the furnace body, which is enclosed in an arched brickwork casing. The electrodes are of carbon, and are mounted on trolleys running on rails. The central electrode forms the hearth of the furnace and is connected to the positive conductor, while the inclined side electrodes are attached to the negative conductor, and form, with the hearth, a trough-shaped furnace body in which the materials to be heated are placed. The electrodes possess a large superficial area, and are made up of large blocks covered and surrounded by a mass of smaller pieces of carbon. Air circulation is used to keep the under-sides of the trolleys carrying the hearth and sides of the furnace cool. The article is illustrated.

J. B. C. K.

REFERENCE.

145. van der Waals' Free Energy Surface for Mixtures of Two Substances. C. M. A. Hartmann. (*Journ. Phys. Chem.* 5. pp. 425-498, Oct., 1901.)—This paper contains a survey of van der Waals' theory of binary mixtures and of experimental work done in connection therewith. It consists of three parts, of which the first treats of the Ψ -surface and conceptions derived therefrom, reviewing that part of the theory which relates to the first plait of the surface, the second contains the consideration of special questions, while the third is a compilation of all experiments which may be brought into relation with the first plait of the Ψ -surface. W. E. T.

STEAM PLANT, GAS AND OIL ENGINES.

STEAM PLANT.

146. *Triple-Expansion Engines, South Shields.* (Engineer, 92. pp. 898-400, Oct. 18, 1901.)—This paper contains a description of the type of engine supplied by J. and H. McLaren, of Leeds, to work in connection with a 500-kw. alternator. The engine is capable of developing a maximum overload of 1,000 i.h.p. at 125 r.p.m., with a steam pressure of 160 lbs. per square inch; cylinders 19½, 80½, and 48 inches diameter by 24-inch stroke, all steam-jacketed; balanced slide-valves; surface condenser of ordinary type. The steam used is taken direct from boilers of the marine type, without any drying or superheating. A special feature is the speed-regulating gear which is applied to the crank-shaft governor. The normal speed of the engine is 120 r.p.m., but by means of this appliance the governor may be set, while the engine is running, to govern at any desired speed within 5 per cent. above or below the normal.

The following figures are from the results of a trial by W. Hartnell, of one of these engines at South Shields:—

Load	Full	$\frac{3}{4}$	$\frac{1}{2}$	$\frac{1}{4}$
kw.	517	390	252	115.4
Steam chest pressure	161.4	164.9	164.7	157.3
r.p.m.	125.3	125.8	125.6	125
i.h.p.	780	637.6	447.5	264.7
Jacket water. Lbs. per hour	587	598	527	276
Total condensed water (jackets and cylinders)	10,440	8,087	5,609	3,455
Total steam per i.h.p. hour. Lbs.	13.44	12.66	12.52	13.08
" " kw. hour	20.19	20.7	22.5	29.9

H. R. C.

147. *Test of a Triple-Expansion Engine.* H. Lorenz. (Zeitschr. Vereines Deutsch. Ing. 45. pp. 649-654, 1901.)—The engine had been working day and night for a year in the Norddeutschen Portland cement factory at Misburg; its normal load is 700 i.h.p., its maximum 900 i.h.p., the cylinder diameters are 475, 750, and 1,200 mm. Two tests were made, one with steam-jacket, the other without. The steam consumption per i.h.p.-hour was in the two cases 5.45 and 5.67 kilos respectively, when working at 600 i.h.p. The consumption was determined by measuring the feed-water, and consequently includes all losses in jackets, &c. The steam consumption in the jackets was 0.80 kilo per i.h.p.-hour. The work done in the intermediate cylinder was not altered by the steam-jacket; that done in the high-pressure was diminished, and in the low-pressure increased. The actual figures were, for high, intermediate, and low-pressure cylinders respectively, without steam-jacket, 239.8, 147.7, 210.4—total, 597.8; with steam-jacket, 188.3, 145.7, 265.3—total, 599.3. To obtain greater accuracy in determination of the boiler water level, the author recommends that a curve be plotted between the water level and time, and that the feed-pump be worked either uniformly or at regular intervals. G. H. B.

148. Engines for large Dynamos. C. Day. (Electrician, 48, pp. 23-26, Oct. 25, 1901. Paper read before the Manchester Association of Engineers, Oct. 12, 1901.)—The author describes the type of engine made by the Ferranti Company. It is a vertical compound engine having the dynamo between the two bearings and the cranks outside; the engines are completely enclosed, and continuous lubrication is secured by means of an oil pump and filter. The speed of the 1,000 h.p. size is 214 r.p.m. With a view to securing the economy of the slow-speed Corliss engine, the cylinders each have four valves—i.e., steam and exhaust valves at each end; these valves are of the grid type, and are placed in the cylinder covers, being worked by cams which rotate at half the speed of the engine. The cam-shaft and the whole of the gear for actuating the valve spindles are collected midway between the cylinders, and enclosed in a box which is kept filled with oil. The steam valve spindle is pivoted to the middle of a rocking lever, one end of which is operated by the opening cam and the other by the closing cam; the angle of advance of the latter is altered by a relay piston controlled by the governor, and thus the point of cut-off is varied to suit the load. The exhaust valve is worked directly from one cam. A test of a 500-h.p. engine at Cardiff electric lighting works gave 15.6 lbs. of steam per i.h.p.-hour, and 24 lbs. per kw.-hour, with a boiler pressure of 140 lbs. and a vacuum of 18.7 inches. An allowance for the bad vacuum of the separate condensing plant reduces these to 13.8 lbs. per i.h.p.-hour and 21.8 lbs. per kw.-hour. H. R. C.

149. Measurement of Cyclic Irregularity in Engines. R. Franke. (Elektrotechn. Zeitschr. 22, pp. 887-892, Oct. 24, 1901. Paper read before the ninth Jahresversammlung des Verbandes Deutsch. Elektrotechn. in Dresden.)—The cyclic irregularity of an engine is defined as the ratio of the difference between its maximum and minimum velocity in any one cycle, to its mean velocity. The author points out the great difficulties met with in measuring this ratio, the chief being perhaps the continual variation in the mean velocity. He describes Radinger's method of measurement, in which a tuning-fork traces a wavy line on a smoked cylinder attached to the engine shaft; Göpel made an apparatus on this principle in an improved form, but the method is far from sensitive, and useless for measurement of small irregularities of 1/100 and less. Schäfer and Budenberg's apparatus consists of a disc attached to the engine shaft, and a flywheel turning freely on the same axis; the disc and flywheel are geared together by a planet gearing, whose axis, perpendicular to that of the wheel carries a pencil point tracing on a rotating drum. The flywheel is turned through the planet gearing, and takes up the mean speed of the engine; as it is too heavy to follow the cyclic variations in speed of the disc, these cause the axis of the planet gearing to move backward and forward round the axis of the disc, and the pencil point therefore traces a periodic curve on the drum. This curve, however, does not give the difference in velocity, but the relative change in position of the disc and flywheel, and the maximum difference in velocity must be calculated from the two steepest tangents to the curve. This apparatus is troublesome in the calculation of results and is not sufficiently sensitive for small irregularities. Another apparatus is constructed on the principle of Hefner von Alteneck's transmission dynamometer, a pulley attached to the engine shaft being connected by a belt to a flywheel, which takes up the mean velocity of the engine; the variations in velocity produce variations in the tension on the two sides of the belt, and an index is arranged to measure these. The elasticity of the belt renders this apparatus unsuitable for any absolute measurements. An

apparatus constructed by the author consists of a heavy cylinder, mounted on an axis fixed to the engine shaft by ball bearings; the friction in these causes it to take up the mean velocity. A frame fixed to the shaft embraces the cylinder, and carries a pencil point which is free to move along a generator of the cylinder. A string attached to the pencil passes over a pulley to a sleeve running free on the axis; if this be held still, the string winds up on it, and pulls the pencil along the cylinder. As the motion of the cylinder is uniform, while the pencil follows the irregularities of the engine, the latter traces a curve, from which the cyclic irregularity can be reckoned. This apparatus was found to work well, but was not sufficiently sensitive for small irregularities.

The only method which the author has found capable of measuring an irregularity of less than $1/100$, is to employ a small independently excited dynamo driven by the engine, and take its curve of volts by means of a Joubert contact-maker and potentiometer; as the volts are proportional to the speed, this gives also the curve of speed of the engine. If there be no irregularities in the dynamo pressure due to its construction, this method is capable of giving very accurate results, but it is troublesome and quite unsuited for practical work.

The author then deals with the effect of cyclic irregularities, more especially with regard to the parallel running of alternators. He considers that in many cases, for instance with gas engines, parallel running is rendered more difficult by the use of heavy flywheels, as the inertia of the engines is then so great that they cannot sufficiently quickly alter their speed in response to the equalising currents in the alternators. He thinks there is no need to attain a smaller cyclic irregularity than $1/200$. G. H. B.

150. *Boilers and Engines for Superheated Steam. Hunger.* (Zeitschr. Vereines Deutsch. Ing. 45, pp. 597-608, 1901. Paper read before the Bezirksverein at Essen, Nov. 14, 1900.)—Scale drawings are given of two boilers with superheaters, and the author in describing them mentions various points to be observed in installing a superheater. Independently fired superheaters are uneconomical, as the gases must be cooled by admixture with air before reaching the tubes.

The author then describes a horizontal tandem compound engine, built for superheated steam, with cylinder diameters of 350 and 600 mm. and stroke of 900 mm. The principal features of the engine are: The high-pressure cylinder is turned perfectly cylindrical on the outside, so that its expansion may be symmetrical, without causing any distortion; the trip-valve chambers are very massive, and fixed by flanges to each end of the cylinder. The piston is very long, about half the length of the stroke, and has two or three Ramsbottom rings; the glands have cast-iron rings and asbestos packing. The author recommends that steam mains for superheated steam be given only from $\frac{1}{4}$ to $\frac{3}{4}$ of the section commonly used for saturated steam. Water-traps are very necessary, owing to the excessive condensation at starting, and to the presence in the steam of particles of solid matter from the superheater tubes. The quantity of lubricating oil required is no more than with saturated steam.

Particulars are given of tests made on an old pumping engine, which had been working at 5 atmospheres pressure, and was later supplied with a boiler for 10 atmospheres and superheater. At 5 atmospheres, without steam-jacket, the steam consumption per i.h.p.-hour was 9.44 kilos and with steam-jacket 8.58 kilos; in the boiler 1 kilo of coal gave 5.66 kilos of steam. At 10 atmo-

spheres, and 286° C. superheat, the consumption was 5.96 kilos per i.h.p.-hour, the boiler giving 5.76 kilos of steam per kilo of coal of 6,900 calories heating value. A 200-h.p. tandem engine showed, with 346° superheat, a consumption of 4.48 kilos per i.h.p.-hour. G. H. B.

151. *Selection of a Steam Boiler.* **W. E. Snyder.** (Street Rly. Rev. 11, pp. 789-790, Oct., 1901. Abstract of a paper read before the Engineers' Soc. of West. Pennsylvania.)—The author gives some useful advice as to the importance of obtaining practical knowledge of the fitness of a boiler design for the special circumstances of its work, and recommends that the following points should be investigated before any boiler is selected:—(1) Safety; (2) convenience of manipulation; (3) steaming properties; (4) durability, and (5) cost. Under the head of Efficiency as a Steam Generator he remarks that the practice of rating the evaporative performance by h.p. is defective, and that the area of heating surface allowed per h.p. should be stated for each boiler, as well as the total efficient heating surface and its distribution. The evaporative results in boilers are proportional to the amount of surface in efficient operation, and not to the total heating surface. Moisture in steam depends more on conditions of work than on design. 1,200 tests of different types of boilers showed in general steam commercially dry or containing less than 2 per cent. moisture, although a boiler on one occasion yielded 8 per cent., and afterwards less than 0.5 per cent. Durability and economy of working generally depend upon facility for cleaning. As the boiler is the heart of the whole installation, its suitability is a vital factor which should not be left to the kind of engineering skill provided by the boiler-making companies.

F. J. R.

152. *Combustion of Fuel.* **A. Bement.** (Amer. Electn. 13, pp. 484-486, Oct., 1901.) [See also Abstract No. 1989 (1901).]—In this paper the author describes the construction and use of various forms of apparatus devised for indicating the proportions of CO₂, O, and CO in furnace gases. The instruments noticed are Orsat's, which provides for measuring 100 cub. cm. of gas, and absorbing the various constituents in U-tubes containing suitable reagents; Arndt's "Econometer," which continuously weighs a moving sample of gas after it has been passed through filters and an absorbing tube for removal of moisture, the excess of weight over that of air showing on the scale over which the pointer moves the percentage of CO₂ contained; and the "Composimeter" which reduces the volume of the gas by removing the CO₂, the consequently reduced pressure being indicated by a water column moving over a graduated scale. Hempel's apparatus is also mentioned as suitable for more complete examination of the constituents of gases in laboratory work, but the three first-named instruments can be attached to, and used in, the boiler-room of a central station in order to show whether the combustion of the fuel is being conducted efficiently. Illustrations of the Orsat apparatus and the Econometer are given in the paper.

F. J. R.

153. *Tests of Automatic Stokers.* (Eng. News, 46, pp. 345-346, Nov. 7, 1901.)—This article contains the official report of a comparative test of underfeed "American" automatic stokers firing Stirling boilers, and "Roney" stokers firing Babcock-Wilcox boilers at the works of the General Electric Company at Schenectady, N.Y. The report is signed by J. E. Denton, Professor at the Stevens Institute, Hoboken, N.J., F. W. Dean, and G. H. Barrus, the engineers appointed to make the tests in accordance with the standard code of the

American Society of Mechanical Engineers. These tests showed that with coal of an average quality yielding not less than 14,500 B.Th.U. by standard calorimeter, the Stirling boiler with American stoker evaporated 11'889 lbs. gross, or 11'743 lbs. net, water from and at 212° F. per lb. of dry coal, and developed 716 gross h.p., or 705 net h.p., the rated capacity of the apparatus being 517.5 h.p. The Babcock-Wilcox boiler and Roney stoker gave a net evaporation of 11'169 lbs. of water as above.

The cost of fuel per annum in each case, taking coal at \$3 per ton of 2,240 lbs., is shown as follows:—

For Babcock-Wilcox boiler—

$$\frac{84.5 \times 24 \times 360}{11'169} = 26,698 \text{ lbs., or } 11'92 \text{ tons, costing } \$35.76.$$

For Stirling boiler—

$$\frac{84.5 \times 24 \times 360}{11'421} = 26,093 \text{ lbs., or } 11'65 \text{ tons, costing } \$34.95.$$

The total costs are stated as follows:—

	American Stoker.		Roney Stoker.
Costs per h.p. per annum.	1.	2.	3.
Cost of coal	\$34.95	34.95	35.76
„ repairs.....	0.77	0.12	0.48
Wages of firemen and helpers	1.44	1.44	1.44
Interest and depreciation	0.88	0.88	0.88
Total cost	\$37.54	36.89	38.06

Column No. 1 gives repairs according to three months' record in log-book.
Column No. 2 gives repairs guaranteed in contract. F. J. R.

154. *Modern Power-house.* J. H. Vail. (Street Ry. Journ. 18. pp. 478-479, Nov., 1901. Paper read before the Amer. Street Ry. Association.)—Steam-engine efficiency having reached practically the highest point, additional economies must be sought in accessories. The author proposes a combination of the use of pulverised fuel, superheated steam, and cooling towers for condensing. The first two have been investigated in cement works and at Milwaukee [see Abstracts Nos. 2231 and 2232 (1901)]. Regarding the third [see Abstract No. 1985 (1901)], the author quotes special experience with the Twenty-sixth Street station of the New York Edison Company, which was designed by him in 1887 and started in 1888. The maximum equipment was limited to 2,600 h.p., with the best selection of apparatus then obtainable. Now, however, with the originally designed boiler capacity, the maximum capacity has been increased to 6,000 h.p., through improved engines and dynamos, with the application of a cooling tower and condenser system.

Upwards of five hundred cooling-tower installations exist, ranging in capacity from 250 to 12,000 h.p., the results being in most cases excellent. Results from the open cooling tower at the Plainfield, N.J., power station during July, 1901, are quoted, showing an average vacuum of 25.17 inches and 80° average reduction of temperature of condenser water. With the fan type of cooling tower results show that with an atmosphere temperature of 98° F. and condenser discharge of 180°, 37° of heat were extracted and a vacuum of 24½ inches obtained by passing the water through the tower. A

fan tower is also used at Plainfield, extracts from the log of which are given. The author advocates giving a liberal margin of capacity in such installations, because a heavy load may come on under adverse atmospheric conditions. The cooling water should be estimated at not less than thirty times the steam consumption of the engine, and two thousand times more air than water will be required. The degree of heat extracted from the water by passing through the tower is affected by atmospheric temperature, humidity, &c., but actual results show a range of from 30° to 50° F. reduction of temperature, and a vacuum of 23 to 27 inches is readily obtained. There will sometimes be 1 to 3 per cent. loss of water due to evaporation in the tower, but when the circulating water is kept separate from the boiler feed, that can be made up at slight cost.

F. J. R.

155. *Purification of Boiler Feed-water.* (Mech. Eng. 8, pp. 549-554, Oct. 26, 1901.)—This is a summary of a section of C. E. Stromeyer's memorandum as chief engineer, to the annual meeting of the Manchester Steam Users' Association. Nine of the principal processes in use for softening calcareous waters were inspected by the chemist of the Association. All the processes are based on the use of lime-water, or milk of lime, for the removal of temporary hardness, and of sodium carbonate for permanent hardness. Most of them are continuous in action, only one of those described being intermittent. The precipitation of the lime salts, and especially of the calcium sulphate, being slow, the different processes exemplify various methods of overcoming the inconvenience of having large settling tanks or of employing filters. These methods are classified as follows:—(1) The treated waters are mixed with old sediment. (2) They are mechanically stirred. (3) They are stirred by air-jets. (4) They are heated. (5) After having settled, the nearly clear fluid is treated with carbonic acid, which dissolves the remaining sediment. The reporter considers 1 and 2, if used with filters, to be fairly satisfactory, but does not favour the use of baffle-plates in the settling towers. He thinks heating, as in 4, expedites the chemical action and the deposit of scale-forming material, but points out that the heating should take place before and not after purification. Nos. 3 and 5 are objected to on account of their charging the water with corrosive agents. Installations of the following systems are described:—The Porter-Clark continuous water-softener, the Stanhope, the Atkins, the Tyacke, the Wollaston, the Brunn-Lowener, the Desrumaux, and the Reisert processes and apparatus, which are all continuous in action, and the Archbutt-Deely system, which is intermittent.

Diagrammatic representations of the various apparatus are given, and also a few chemical analyses of waters before and after treatment.

F. J. R.

GAS AND OIL ENGINES.

156. *Acetylene Motors.* **H. Cuinat.** (Locomotion Automobile, 8, pp. 616-618, Sept. 26, 1901. From *La Chronique Industrielle*.)—Some figures are given relating to the properties of acetylene, and also the results of actual experiments on motors using this gas. An engine tested in 1896 with acetylene gas in the proportion of 1 gas to 20 air, developed 6 h.p., with a consumption of 175 litres of gas per h.p.-hour. The same engine consumed 516 litres of ordinary lighting gas per h.p.-hour at the same power. With acetylene the compression pressure was 8 kg., and the explosion pressure 29 kg. per sq. cm. In the case of a 3-h.p. Otto engine tested by the "Gas

Motoren Fabrick Deutz," the consumption of gas per h.p.-hour was 225 litres at 15°C. The compression pressure was 12.59 kg., the explosion pressure 43.6 kg., and the final pressure on exhaust 8.87 kg. per sq. cm. The proportion of gas and air varied from 1 to 25 to 1 to 30. C. R. D'E.

157. *Methods of Increasing the Power of Petrol Motors.* G. Laverigne. (Locomotion Automobile, 8, pp. 609-610, Sept. 26, 1901.)—The author points out that in 1895 the de Dion motor weighed about 36 kg. per h.p., and in 1900 the weight per h.p. for the same type of motor had been reduced to 9.4 kg. The 16-h.p. Buchet motor for the No. 5 Santos Dumont flying machine weighs 5.8 kg. per h.p. The following means of augmenting the power of motors are pointed out:—Adding oxygen gas to the explosive mixture; increasing the size of the silencer, and so reducing the loss due to back pressure on exhaust; increasing the pressure of compression, which at present varies from 2.5 to 5 atmospheres, and might possibly be increased to 7 atmospheres with advantage; increasing the speed of rotation, which is limited by the fact that the velocity of the piston must be considerably less than the velocity of inflammation of the explosive mixture. Buchet finds in practice that the limit of piston velocity is between 4.5 m. and 5 m. per second. With higher compressions the piston's velocity might be increased. C. R. D'E.

158. *Alcohol Motors.* L. Perissé. (Locomotion Automobile, 8, pp. 625-626, Oct. 3; 641-642, Oct. 10; 657-659, Oct. 17; and Discussion by A. Lecomte, pp. 673-674, Oct. 24; and pp. 705-706, Nov. 7, 1901.)—The author opens this series of articles by pointing out the advantages which alcohol possesses in being a fixed and homogeneous chemical compound. Alcohol can now be obtained commercially in an almost chemically pure state. It possesses the advantage over petrol that it can be made and used in any climate. In France what is known as *pure commercial alcohol* has the following composition: Ethyle alcohol (90 per cent. rectified), 100.0 litres; methyle alcohol (90 per cent. rectified), 10.0 litres; heavy benzine (distilling between 150°-200° C.), 0.5. In order to increase the calorific value and decrease the price of this alcohol it is carburetted with light benzine, which boils between 80°-120° C., the mixtures usually employed for motors containing either 25 per cent. or 50 per cent. of the latter. The heats of combustion per kilogramme of the *pure commercial alcohol* and of these two mixtures are 5,111, 6,159, and 7,145 calories respectively. The price of pure commercial alcohol varies from 0.55 fr. to 0.60 fr. per litre, and that of carburetted alcohol is 0.45 fr. per litre. Various forms of carburettors for alcohol motors are mentioned, amongst those most frequently used being the spray-making carburettors of Longuemare [see Abstract No. 1144 (1900)], Martha, and le Blou [see Abstract No. 900 (1900)]. Certain figures are given, obtained from the results of three contests between motor vehicles employing alcohol, held in France during 1901. At Deauville the mean speed for the flying kilometre was at the rate of 81.810 km. per hour for carburetted alcohol, and 76.200 km. for pure alcohol. With a 20-h.p. Darracq car the speeds obtained for the flying kilometre were 90 km. per hour with petrol, 81.8 km. per hour with carburetted alcohol, and 65.45 km. per hour with pure alcohol. The author comes to the conclusion that in motors employing alcohol the ratio of the length of stroke to the bore of cylinders and the compression should both be as great as possible.

Some figures are given relating to vehicles for heavy goods, propelled by alcohol motors, which took part in certain trials between Paris and Achères

(25 km.). The lorry of the "Société naucéenne d'automobiles," Brillié system, which weighed 2,500 kilos empty and carried a load of 3,877 kilos, travelled at an average speed of 8.7 km. per hour and consumed 0.095 litre per tonne-km. of total load, the alcohol being carburetted with 50 per cent. of benzine. The engine was of 10 h.p. with two vertical cylinders each with two pistons. The de Dietrich and Panhard Levassor lorries also gave good results. Amongst the lighter vehicles the 6-h.p. Panhard Levassor vehicle, weighing 990 kilos empty and carrying 913 kilos, consumed 0.098 litre per tonne-km. of this mixture. As a result of certain trials held in Germany of an alcohol motor-lorry the following figures are given:—Weight of vehicle and load, 3,242 kilos; useful load, 1,092 kilos; daily journey during seven days, 36.85 km.; consumption of alcohol-carburetted with from 20 to 25 per cent. of benzine, 0.107 litre per tonne-km. of total load. C. R. D'E.

159. *Coolers.* (Locomotion Automobile, 8, pp. 587–588, Sept. 12, 1901).—Two forms of water-coolers for internal combustion engines are illustrated and described. The first is intended for use on a motor tricycle, and consists of a combination water, petrol, and oil tank of corrugated metal, together with a length of corrugated tubing attached below the tank. The second form consists of a shallow hexagonal tank pierced by numerous tubes, through which air is sucked by a fan driven by the motor. C. R. D'E.

160. *Kêcheur Carburettor.* P. Sarrey. (Locomotion Automobile, 8, pp. 582–583, Sept. 12, 1901).—This carburettor is of the type in which the suction of the motor cylinders raises a light spring-controlled valve, which closes both the main air supply and the petrol jet. The injected petrol runs down the exterior walls of a chamber which is heated by the exhaust gases, and the vapour mixes with the indrawn air, which also passes around the heated chamber, and thence to the motor cylinder. A sectional elevation is given. C. R. D'E.

AUTOMOBILISM.

161. *The Design of Automobiles.* W. A. T. Müller. (Centralblatt Accumulatoren, 2, pp. 221–224, Aug. 15; 235–239, Sept. 1; 245–249, Sept. 15; and pp. 257–260, Oct. 1, 1901).—These articles continue the discussion of the general principles underlying the design of automobiles. The first two articles contain a further examination of the connection between tractive effort and the diameter of the wheels, the author arriving at a formula which corresponds almost exactly with that given in Abstract No. 1896 (1901). All authorities agree that the coefficient of rolling friction is less with wheels of large than with those of small diameter; but there is difference of opinion as to the precise relation between the tractive effort, the load to be drawn, the diameter of the wheel, the width of tyre, &c. [See also Abstract No. 587 (1901).] The author, however, points out that the vibration of the vehicle tends to increase the tractive effort necessary, and that the latter does not depend directly on the load drawn. For instance, a car weighing 2,050 kg., took 44 amperes at 75 volts on the level, when carrying one person. If the load was increased to six passengers, i.e., by 18 per cent. of the whole, the current increased by rather less than 1 ampere; and this cannot be explained by any of the formulæ proposed. A mathematical consideration

Electric Automobiles are described in the Section dealing with Electric Traction.

of the question leads the author to the conclusion that the loss of energy through shocks is inversely proportional to the diameter of the wheel. His practical conclusions are as follows:—(1) That the wheels should have large diameters; (2) that the wheels and axles should be as free as possible from any of the working mechanism; (3) that the car springs should be so constructed as to undergo a considerable deformation with a slight increase of load; and (4) that the upper part of the car together with all its appurtenances should be rigidly connected together. W. H. S.

162. *Testing Power Losses in Motor Cars.* P. Gasnier. (Ind. Élect. 10. pp. 469-471, Oct. 25, 1901.)—After criticising the methods employed in recent trials of the efficiency of motor cars, *i.e.*, of the ratio of the power available at the rim of the wheel to the power at the motor spindle, a description is given of a new method which will obviate any necessity for determining sundry small losses. The author proposes to have an endless moving platform on to which the car to be tested will be driven with all its passengers. The car is held to a rigid support by a spring balance, and the wheels work the moving platform. Any desired surface can be imitated by putting more or less brake, mechanical or electrical, on to the moving platform. It is only necessary to read the spring balance and the speed of the platform, or of the wheels, in order to determine directly the power at the rims of the wheels. The effect of the car's kinetic energy in making the engine run steadily might be imitated by moving the whole apparatus at a speed corresponding to the speed of the car wheels. Careful tests of an electric car on such an apparatus, with different wheels, tyres, &c., might accurately determine the coefficients of traction, and the effect of different tyres and various wheel diameters, as to which the present data are very vague. E. H. C.-H.

163. *House Steam Car.* (Automotor Journal, 5. pp. 586-588, Sept., 1901.)—This is a four-seated pleasure vehicle, with the mechanical parts all carefully enclosed and the boiler almost completely out of view within the carriage body. The boiler is of the vertical fire-tube type, 20 inches diameter by 16 inches high, and is fired by a liquid fuel burner consuming ordinary petroleum. The working pressure is 250 lbs. per square inch. The engine is of the horizontal compound type, but special arrangements are fitted for using, when desired, full pressure in the l.p. cylinder, and the transmission mechanism consists simply of a single spur gear from the crank-shaft to the exterior of the differential gear on the rear, or driving, axle. The casing, enclosing the engine and gearing, is attached to the tube surrounding the rear axle, and the front end of the engine is slung from the underframe by a single pivoted tie-bar, which allows the whole mechanism to play up and down with the axle. The weight of the vehicle unloaded is 16 cwt. The paper is illustrated by photographs. C. R. D E.

164. *Yorkshire Steam Motor Waggon.* (Automotor Journal, 6. pp. 10-11, Oct., 1901.)—In this waggon the boiler is mounted at the front of a channel steel frame, and the engine cylinders are mounted at either side of the frame below the waggon body. The transmission from the crank-shaft to the driving axle is by spur gearing throughout.

The boiler consists of a cylindrical drum, at the centre of which, and projecting below it, is the fire-box. At either end of the drum are smoke-boxes connected by fire tubes to the fire-box. From these smoke-boxes tubes pass

back to a central smoke-box above the fire-box, and the products of combustion escape thence through a vertical chimney. The doors of the end smoke-boxes contain chambers for receiving the exhaust steam, and the steam escapes thence by nozzles which project into the tubes connecting the end and central smoke-boxes. The boiler is mounted with the length of the drum transverse to the length of the waggon frame. The engine crank-shaft is mounted in bearings on the waggon frame, and lies parallel to, and in front of the rear axle; the cylinders being at either side, outside the frame, and the pistons coupled to cranks at the ends of the crank-shaft. The transmission is first by spur gearing to a counter-shaft carried in bearings on side brackets pivoted from the underframe; the arrangement being such that the radial distance between axle and counter-shaft, and counter-shaft and crank-shaft, are kept constant. The counter-shaft then drives the axle by a pinion, gearing with a spur wheel mounted upon the differential gear.

C. R. D'E.

185. *Wolseley Motor Car*. (Automotor Journal, 6. pp. 6-7, Oct., 1901.)—In this vehicle a horizontal double cylinder petrol engine is mounted at the front end of a channel steel underframe, with the cylinder centres slightly below the frame level, and the crank-shaft lying at right angles to its length. The transmission from the crank-shaft to the rear wheels is effected, firstly, through a cone clutch and a Renold's chain drive to the change-speed gear, and thence by independent roller chain drives to the wheels. In the change gear four speeds forward and one reverse are obtained by means of spur wheels and pinions brought into engagement by side contact, and the differential cross-shaft of the change gear carries at either end the sprocket pinions of the final chain drives. The front portion of the frame is covered by a bonnet the sides of which are surrounded by the tubes of the radiator for cooling the cylinder jacket water. At its back end the bonnet abuts against the dashboard. The petrol tank is enclosed within the bonnet and attached to the front of the dashboard. The underframe is attached by single plate springs to the axles. Wheels of equal diameter front and back are employed. The steering wheels are pivoted on the Ackerman system, and their direction is controlled from a hand-wheel which operates through a bevel and a worm gear. A band-brake on the differential cross-shaft and powerful shoe-brakes acting on drums attached to the rear wheels are provided.

C. R. D'E.

186. "*Roze*" *Flying Machine*. G. Joula. (Locomotion Automobile, 8. pp. 566-568, Sept. 5, 1901.)—This machine consists of two cigar-shaped balloons, parallel and in a horizontal plane, joined by a framework of aluminium tubes, which carries the operator, the motor, and four propellers, two for lifting the machine and two for propelling it horizontally. The balloons are each 45 m. long $\times$ 7 m. in diameter, with a double silk envelope mounted upon a skeleton frame of aluminium tubes. The power is supplied to all the propellers by a 20-h.p. Buchet motor with four water-cooled cylinders. The propellers are each 8.20 m. in diameter, and can be driven simultaneously at 250 r.p.m., or either pair alone at 800 r.p.m. It is calculated that the total weight of the machine will be 2,600 kg., or about 70 kg. in excess of the lifting power of the balloons alone. Steering is effected by a rudder suspended at one end of the central frame.

C. R. D'E.

GENERAL ELECTRICAL ENGINEERING.

167. *Halsey Direct-current Meter.* (Elect. World and Engineer, 88, pp. 281-282, Aug. 10, 1901.)—The meter consists of a copper drum or disc rotating in mercury between the poles of a permanent magnet, the current entering and leaving the mercury path at two points so placed that it passes across the field. Several forms of the meter are described and illustrated. No compensation for friction is provided, as a 25-ampere meter starts with $\frac{1}{10}$ of an ampere, and is only 10 per cent. slow on $\frac{1}{2}$ of an ampere. Variations in the strength of the permanent magnet do not materially affect the constant. G. H. B.

168. *Rotary Field Measuring Instruments.* F. Schrottke. (Elektrotechn. Zeitschr. 22, pp. 657-667; Discussion pp. 667-669, Aug. 15, 1901. Paper read before the Elektrotechn. Verein, Jan. 22, 1901.)—The author describes in full detail the Siemens and Halske alternate-current meter with rotary field [see Abstract No. 1559 (1900)]. The phase-difference of 90° is obtained as follows:—The two pressure windings form opposite arms in a Wheatstone Bridge connection, the other two arms being non-inductive resistances; one diagonal is connected across the mains through a choking coil, and the other joined up by a non-inductive resistance. By adjusting this resistance, the current in the pressure windings can be brought into quadrature with the pressure. As the choking coil takes up the greater part of the pressure, the arrangement does not require coils of high resistance. The loss in the pressure circuit at 120 volts is 1 watt. The auxiliary turning moment to compensate for friction is produced by niches in the iron core opposite the pressure coils; these niches produce a dissymmetry in the field due to the pressure coils, and a consequent increase or decrease of turning moment according to the position of the niches relative to the coils. The core can be rotated by a lever held by two screws, and by these the compensating torque can be adjusted from the outside of the case. To avoid running on open circuit the drum has three or four cuts made on its lower edge; it then places itself so that the induced current is a minimum and requires a certain force to move it from this position. The lower bearing of the moving system is supported on a spring which is kept in vibration by a small electromagnet; this avoids starting friction, and prevents a change in the constant when the meter is subjected to outside vibration. The change in the constant due to variations of frequency is very small, and the meter reads accurately on inductive circuits up to 75° lag. A meter was shown accurate to within 1 per cent. from 1 per cent. to 130 per cent. of full load, and starting at 0.2 per cent. of full load. For three-phase currents two meters are mounted with one moving system; the current field is made to lag about 80° behind the current by means of a short-circuited winding, so that the lag of the pressure current behind the pressure can be made 90° , a lag entailing less loss of energy in its production than one of 60° .

The author then describes indicating instruments constructed on the same principle as the meter, but with a controlling spiral spring. The scales are given any desired form by combining a gravity control with the spring. An ohmmeter is made, consisting of a voltmeter, one winding of which is connected across the mains, and the other between one main and a two-way

switch, connecting either to earth or to the line to be tested, which is connected also to the other main. When the switch connects to earth the instrument indicates the insulation-resistance at normal pressure; with the switch in the other position it indicates the pressure; if this differs from the normal a correction must be applied.

The current transformers for large currents are constructed in a novel way to avoid the influence of outside fields. The bar carrying the main primary current is bent to a U shape, with its plane at right angles to it; the iron circuit is E-shaped, the middle bars passing through holes in the U-legs, and forming the core of the secondary coil. With this arrangement no current would be induced in the secondary, but a dissymmetry is produced in the primary circuit by cutting away portions of the U on opposite sides on the two legs, and it then magnetises the iron circuit. The secondary circuit is then secure from induction by any conductors outside the iron circuit. High-tension transformers for instruments are insulated entirely by porcelain; the primary is wound on a porcelain tube, provided with ridges, forming separate channels which subdivide the winding, and the whole is enclosed in a porcelain case, and filled with insulating material run in *in vacuo*.

Discussion.—**Benischke** referred to the form of current transformer adopted by the Allgemeine Elektrizitäts-Gesellschaft, which can be fixed round the main conductor itself, without cutting it. **Dolivo-Dobrowolsky** mentioned methods of obtaining a current in quadrature with the pressure other than that described by the author. G. H. B.

169. *Magnetic Brakes.* **K. Feussner.** (Elektrotechn. Zeitschr. 22. pp. 608-611, July 25, 1901. Paper read before the Elektrotechn. Verein, April 23, 1901.)—The author, after pointing out the need for a more accurate form of measuring brake than the Prony, describes two forms of magnetic brakes which have been in use at the Reichsanstalt for testing small motors. In each form a copper disc is mounted on a shaft, and two electromagnets embracing the disc are fixed to a frame which is hung on knife-edges, and provided with a scale-pan for weights. The rotating disc exerts a force on the magnets, which is counteracted by the addition of weights in the scale-pan, till the magnet frame is brought back to zero, as indicated by a pointer. The load is varied by varying the exciting current of the electromagnets. The copper disc is made hollow and water circulated through it by centrifugal force for cooling. The author then deals with the theory of the brake, and shows that the reaction of the induced currents on the magnet field plays an important part. Were there no reaction, the torque exerted by the disc would increase proportionately with the speed, instead of which it diminishes. Of the two brakes used by the author, one showed an increase and the other a decrease of the torque as the temperature, and consequently the resistance, of the disc increased. G. H. B.

170. *An Electric Tachometer.* **É. Hospitalier.** (Ind. Elect. 10. pp. 519-520, Nov. 25, 1901.)—A condenser of capacity C is alternately connected to a battery of e.m.f. E , and discharged through a very dead-beat moving coil voltmeter, by means of a contact on the shaft whose speed is to be measured. If ω is the frequency of charge and discharge, the mean current is $I = \omega CE$. At high speeds the impedance of the voltmeter may prevent the condenser from discharging completely. This may be overcome by using a suitable voltmeter, but it then requires either a large capacity or high e.m.f. Where only low volts are available a transformer may be used, the secondary

being connected to the voltmeter. The voltmeter circuit is both closed and broken just before the primary circuit, so that the voltmeter only takes the current due to closing the primary circuit.

R. B. R.

171. *High-Tension Fuses*. **G. Semenza**. (Elettricità, Milan, 20. pp. 488-489, Aug. 8; and pp. 499-500, Aug. 10, 1901. Paper read before the Milan branch of the Associazione Elettrotecnica Italiana.)—The author describes the various forms of high-tension fuses now in use. Of those in air, he prefers the type in which the fuse wire is enclosed in a tube open at the ends, so that the expansion of the air blows out the arc. When used for large currents the amount of metal vaporised is considerable, and the vapour cloud may cause the formation of an arc between the fuse-blocks. This having frequently occurred in the Paderno installation, the author substituted fuses immersed in oil, and found them in every way more satisfactory. The size of wire for the same fusing current is less in oil than in air, and it is of decided advantage to reduce the amount of metal to be fused. Copper, however, is not suitable, owing to its high temperature with a normal working current. Of pure metals tin was found to have the lowest temperature for a working current taken as a given fraction of the fusing current. A lead-tin alloy of equal parts is still better in this respect, but alloys have the disadvantage of uncertainty in their fusing-points. The ratio of the maximum working current (for a given temperature of the wire) to the fusing current may be increased by the use of heavy oils, such as ordinary cylinder oil. The author has employed fuses in vertical tubes filled with oil on 14,000-volt circuits and obtained satisfactory results.

G. H. B.

172. *Blow-out for High-frequency Arcs*. **A. Soulier**. (Ind. Élect. 10. p. 458, Oct. 10, 1901.)—A description of d'Arsonval's arrangement for preventing the formation of the arc which is apt to form at the spark-gap of a high-frequency apparatus. A small motor has fixed on its spindle an ebonite sleeve to which are attached, in line with each other and with the axis of the spindle, two insulated metal blocks. Through these pass, parallel with each other and perpendicular to the motor spindle, two metal rods terminated by balls, between which the discharge passes. The metal blocks are connected [presumably by means of brushes] with the terminals of the high-tension winding of the induction coil or transformer, and with those of the condenser. When the apparatus is at work, the displacement of air produced by the rapid rotation of the spark-gap is sufficient to blow out each spark as it passes. Incidentally the balls are kept cool, and the deterioration of their surfaces by the spark is retarded. The motor need not absorb more than 30 or 40 watts.

B. P. S.

173. *Lightning Protectors*. **R. Börnecke**. (Zeitschr. Elektrotechn., Wien, 19. pp. 478-482, Oct. 6, and pp. 489-494, Oct. 13, 1901.)—The author discusses the various devices which have been used for the protection of cables against abnormally high p.d.'s due to resonance effects; such devices generally consisting of adjustable spark-gaps, connected on one side to the conductors, and on the other side earthed through high non-inductive resistances, consisting of incandescent lamps or water resistances. He then considers rises of potential due to atmospheric disturbances, and classifies the different forms of lightning protectors into a number of groups. An illustrated description of various typical forms is given. The diameter of the earth wire is generally

not less than 6 mm. As each additional lightning protector increases the chances of interruptions in the supply, it is desirable to limit their number as far as possible. A. H.

174. *Size of Cell Switch Leads.* E. Hunke. (Elektrotechn. Zeitschr. 22. pp. 1006-1010, Dec. 5, 1901.)—This is a mathematical investigation of the most economical size to give to the leads from the regulating cells of a battery of accumulators. Formulæ are deduced for the best current density in terms of the energy cost, price of copper or aluminium, the number of daily charges and discharges, the number of cell leads, and sinking fund and interest. Curves with the main variables are plotted. The influence of rate of change of voltage is minutely examined, according as the cells are charged or discharged. The limits of the calculations, using German prices, vary from about 0.2-1.8 square millimetres per ampere. W. W. H. G.

175. *The Construction of Electromagnets.* A. J. Conor. (Électricien, 22. pp. 344-348, Nov. 30, 1901. A paper read at the Association des Ingénieurs de l'Institut industriel du Nord.)—It is a summary of the chief laws useful in the design of electromagnets, which latter are divided into two classes: (1) Electromagnets with armature in contact, and (2) those pulling from a distance (*à grande course*). In the first case the formula—

$$B = 4965 \sqrt{\frac{F}{S}} \text{ gauss,}$$

where B is the induction and s the area of cross-section in sq. cm., F being the traction in kilos, is useful. For the other case attention is directed to the method of Guénée [see Abstract No. 234 (1901)]. W. W. H. G.

176. *Electrically Operated Locks on the Dortmund-Ems Canal.* Rudolph. (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1009-1017, July 20; and pp. 1405-1414, Oct. 5, 1901.)—There are two electrically operated locks on this canal, the one at Münster and the other at Gleesen. The former is described in this article. The fall of water varies from 6.7 m. to 4.4 m., and is utilised to drive a turbine giving 11 h.p., which in its turn drives a 7-kw. dynamo; this furnishes current for the various motors. A small battery of accumulators is also provided. In case of failure of the electrical apparatus the machinery of the locks is capable of being worked by hand. A large number of drawings are given, showing the way in which the motors are geared to the working parts, and the system of control adopted. The lock is 67 m. long, 9.7 m. deep, and 8.6 m. broad, and is provided with auxiliary side basins to allow for the economical use of water. The time required for working the lock is about 165 seconds, and the energy consumed is on an average 278 watt-hours, including lighting, &c. The amount of water taken by the turbine is 1.4 per cent of the amount required for the working of the lock.

W. H. S.

177. *Electrically Driven Pumps at Horcajo.* F. Heerwagen. (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1549-1559, Nov. 2, 1901.)—The mine of Horcajo is in the Spanish province of Ciudad Real, and, since 1855, has been noted for its silver containing lead ore. The presence of water has always necessitated pumping, and the original machinery has now been replaced by high-pressure centrifugal pumps made by Sulzer, which are directly connected to three-phase motors. The electrical plant has been supplied by

Brown, Boveri & Co. The generators are 20-pole machines, with an exciter on the same axis, which give 1,000 volts at 270 r.p.m. The output is 800 h.p.; with a power-factor of 0.8 the efficiency is 98 per cent. Three more alternators of the same kind, but of 400 h.p., have lately been added. They are all driven by Sulzer engines. The motors are six-pole, and give 250 h.p. at about 900 r.p.m., with an efficiency of 94 per cent, the power-factor being 0.85. They are directly supplied at 1,000 volts. The working of these motors has proved extremely satisfactory. No difficulty has been experienced at starting, and there has been no trouble with respect to insulation. Current is supplied by steel-armoured, lead-covered cables supported on the walls of the shaft. The article is illustrated by many plans and diagrams, and well deserves the attention of engineers who are considering methods of lifting water from deep mines. W. W. H. G.

178. *Travelling Crane.* A. Kolben. (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1518-1519, Oct. 26, 1901.)—The author describes very fully with numerous illustrations and scale diagram, an electrically driven travelling crane, three of which are in use in a steel foundry in Kladno. The crane is driven by three-phase current at 500 volts and 25 $\sim$ and has a span of 11 metres and a capacity of 10 tons. G. H. B.

179. *Electric Travelling Cranes.* (Elect. Rev. 49. pp. 891-893, Nov. 29, 1901.)—Particulars are given of the construction of a motor-driven travelling crane, built by Adamson. The overall efficiency of the hoisting motion of a 10-ton crane is said to be 43 per cent., and figures are given showing the results of the tests on this and other cranes. W. H. S.

180. *Brakes for Cranes.* A. Ernst. (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1081-1087, Aug. 3; and pp. 1123-1129, Aug. 10, 1901. Paper read before the Württemberg section of the Verein Deutscher Ingenieure.)—The greater portion of the paper refers to various forms of mechanical brakes. The latter part, however, contains information as to the working of the Schuckert controller, as applied to cranes built by that firm. The usual diagrammatic sketch of the connections is given, and it is also described in the German Patent No. 120078. The main point is as follows:—the series-wound motor is converted into a generator, which is first short-circuited on itself and then gradually made to discharge through an increasing resistance, the starting-resistance being used for this purpose. Provisions are made by which, in the first stage, the motor is run as a shunt motor, the field and armature windings being thrown into parallel, placed in series with the starting-resistance, and fed with the supply voltage. The falling load and the supply voltage increase the speed to such an extent that the motor is almost instantaneously converted into a generator; the motor circuits are then disconnected from the supply mains, after which it is worked as a series dynamo, the current generated in the armature being kept within limits by the insertion of a smaller or larger portion of the starting resistance. W. H. S.

181. *Solenoid Drills for Hard Stone.* E. Heubach. (Zeitschr. Vereines Deutsch. Ing. 45. pp. 1492-1497, Oct. 19, and pp. 1526-1531, Oct. 26, 1901.)—This article summarises the principles on which solenoidal percussive rock drills have been built, notably by van Depoele, who used a combination of three solenoids surrounding an iron core, the centre one being excited by a

continuous current, and the two end ones by an alternating current, the latter being derived, with a suitably low period, from a continuous-current dynamo, by a pair of brushes revolving on the commutator with a speed governing the period. The more modern construction by Marvin, using two solenoids alternately energised, and the special dynamo for use with this type of drill are described. The method of obviating the difficulties of insulation by mica insulated coils of wire of square section is described. In the second part the electrical working is discussed, and the current and power-factor with various lengths of stroke of the drill are shown by means of curves. The method of winding multipolar generators to give a number of periods, that is of oscillations to the drill, equal to or greater than the number of revolutions of the machine, is described and illustrated. Tables are given of actual results as to speed of working, and cost of wages and sundries extending over a year in 1895, and again in another case for a year in 1899. In conclusion, a comparison of weight and power is given and the respective merits of percussive drills driven by a motor and flexible shaft, with those of the solenoid type are discussed.

LL. B. A.

182. Electric Power in Coal-mines. W. Habermann. (*Zeitschr. Elektro-techn.*, Wien, 19. pp. 409-418, Aug. 25; and pp. 466-471, Sept. 29, 1901. Paper read before the Elektrotechn. Verein, May 1, 1901.)—The paper deals with the application of electric power to pumping, boring, hoisting, and other machines used in coal-mines, with the amount of power required by the different machines, and with the central supply station.

G. H. B.

183. Becker Electric Furnace for the Manufacture of Glass. Bermbach. (*Elektrochem. Zeitschr.* 8. pp. 121-128, Sept., 1901.)—The author, in this lengthy paper, gives details of the present methods of glass manufacture, and states that the consumption of fuel per kg. of finished glass varies from 0.50 kg. in the best type of regenerative gas-fired tank furnace, to 4 kg. in the case of direct hand-fired pot furnaces. In the latter a thermal efficiency of only 18 per cent. is obtained, for thermal calculations show that the calories necessary to produce 1 kg. of melted glass only amount to 746. The thermal efficiency of the regenerative furnaces is stated to be 42 per cent. The experience gained with carbide furnaces has, however, proved that 75 to 80 per cent. of the energy of the electric arc can be utilised for direct heating in suitably constructed furnaces, and therefore it should be possible to produce 1 kg. of melted glass, with a coal consumption of 1.5 kg. in an electric furnace of suitable design.

The possibility of applying the electric furnace to glass manufacture is therefore, in the author's opinion, favourable, for many varieties of glass cannot be produced in the large tank furnaces, and the fuel consumption in gas-fired pot furnaces per kg. of glass produced, is about the same as that calculated for the electric furnace.

Further, the heavy expenditure involved in the erection and repairs of gas furnaces would be avoided, and a longer life might be expected for the electric furnace. Four illustrations are given, showing two types of Becker furnace.

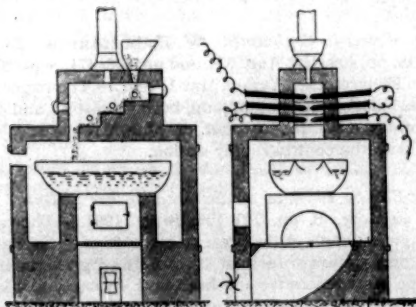
The principle of these furnaces is—to heat the raw materials, lime, sand, and soda, between successive pairs of carbon electrodes, as they slide down an inclined passage into the furnace body, and to complete the heating of the glass, in the latter, either by resistance heating or by gas-firing. As glass in the molten state is an electrolyte, only alternating current can be used for the latter. A 40-volt current suffices for the arc heating.

J. B. C. K.

184. *Experiments in Producing Glass by Electricity.* M. du Welz. (Assoc. Ing. Éli. Liège, Bull. 1. pp. 178-191 ; Discussion, pp. 191-192, Sept. 21, 1901.)—The author gives an account of experiments made by M. Jules Henrivaux in the utilisation of an electric arc for manufacturing glass. In the first place reference is made to the raw materials employed in making various species of glass, as shown by the following table :—

SiO ₂	{	K ₂ CO ₃	{	CaO	Bohemian Glass.
			{	Pb ₃₀ , O ₂₀	
		Na ₂ CO ₃		CaO	
		Na ₂ SO ₄	{	Al ₂ O ₃ , Fe ₂ O ₃	
					Crystal Flint Glass.
					Common Window Glass.
					Very common Bottle Glass.

The ingredients are heated together into a fused mass ; and this has to be maintained for a number of hours at a temperature of from 1,000° C. to 1,200° C. in order to refine it. The refining has to be done carefully, as if the glass is kept near its fusing-point for too long a time, a phenomenon known as de-vitrification occurs, spoiling the glass. It is therefore necessary that when



the glass is ready, and has been allowed to cool to a pasty condition, it should be worked quickly to avoid spoiling.

A description of the generating plant is then given. It is a water-driven three-phase alternating current plant in units of 500 h.p. A stand-by steam-driven set, for use when water is scarce, is in course of erection. The object of the installation is to distribute current to the surrounding villages and factories, up to a distance of 18 kilometres, and for this purpose the current is transformed from 540 volts up to 10,000.

Then follows a description of the glass-making electric furnaces, beginning with the first attempt, and then showing the successive improvements.

Throughout the whole range the principle has remained the same, viz., a series of three steps made of refractory material, on each of which a powerful arc is at work. The glass-making mixture is fed from a hopper on to the top step, and passes successively through the arc on each step, finally falling in molten drops into a basin, where it is kept fused by coke or gas for refining.

Working holes admit of the glass being drawn from this after refining for working, or else a further vessel is attached for the purpose.

The accompanying sections show the most recent form of furnace employed. The results obtained up to the present show that the system is very wasteful of heat as compared with modern gas-fired glass furnaces.

These can be worked with from 1.5 to 2.8 kg. of coal per kg. of glass made, while the figures obtained show that a current equivalent to 9.3 kg. of coal was used per kg. of glass made electrically. The inventors believe that they will finally succeed in reducing this to an equivalent of from 1.0 to 1.5 kg.

The author analyses the results obtained, and suggests improvements. He describes a further improved furnace now about to be started. There are a few words of discussion on the paper.

J. L. F. V.

REFERENCES.

185. *Requirements of Electricity in Manufacturing Works.* W. S. Aldrich. (Elect. Rev. 49. pp. 614-615, Oct. 11, and pp. 650-652, Oct. 18, 1901. Paper read before the Amer. Soc. Mech. Eng. (Milwaukee meeting, May, 1901).—The paper contains a detailed description of the subject under the following heads:—1. General considerations. 2. Economics of electricity in manufacturing. 3. Influence of electric transmission upon factory buildings. 4. Influence of electric transmission upon workshop expansion. 5. Influence of electric drive upon arrangement of machinery. 6. Changing from the old to the new system of driving. 7. Application of the electric drive. 8. Selection of equipment. 9. Losses in factory transmission. 10. Efficiency of electric transmission. 11. Operation and testing of factory installations.

186. *Standardisation of Incandescent Lamp Sockets.* (Elektrotechn. Zeitschr. 22. pp. 647-650, Aug. 15, 1901.)—The Reichsanstalt has undertaken to test sockets &c., with a view to ascertaining whether they conform to the regulations laid down by the Verband Deutscher Elektrotechniker. The article contains a statement as to the limits of allowable error, and a discussion of the reasons for the determination of the said limits.

GENERATORS, MOTORS, AND TRANSFORMERS.

187. *Determination of Efficiency of Dynamos.* **G. Bienaimé.** (Ind. Élect. 10. pp. 517-519, Nov. 25, 1901. Paper read before the Soc. Industrielle du Nord de la France, Oct., 1901.)—The C'R losses are easily calculated, but the other losses must be found by experiment. To do this the dynamo should be run light as a motor, at the same speed and the same volts as it gives in the armature when running as a generator at full load. But if it is impossible to get sufficient voltage to do this, the losses may be found by running it properly excited at two different lower speeds. Since the current required to run it is a linear function of the volts, the current which would be required to run it at the full volts can then be calculated. This is based on Housman's method of separating the losses due to Foucault currents from the losses due to hysteresis and friction. R. B. R.

188. *Theory of Commutation.* **K. Pichelmayer.** (Elektrotechn. Zeitschr. 22. pp. 967-969, Nov. 21, 1901.)—Referring to the papers of Girault, Fischer-Hinnen, and Arnold, the author shows that the necessary condition for sparkless running as established by these authors may be thrown into a slightly different form, which expresses the fact that the mean e.m.f. of self-inductance during the period of the short-circuit must be less than the drop of potential due to the brush contact resistance. This condition is, strictly speaking, applicable only to the case in which the width of the brush approximately equals that of a segment. It may, however, be extended to the case in which several coils are simultaneously short-circuited, the only necessary modification being that to the e.m.f. of self-inductance we have to add the e.m.f. of mutual inductance. This latter is assumed by Parshall and Hobart to be, for two neighbouring conductors, equal to the self-inductance e.m.f. of one conductor. The author's measurements show that the e.m.f. of mutual inductance for two neighbouring coils is only from 80 to 60 per cent. of the self-inductance e.m.f. A. H.

189. *Eddy Currents in the Pole-pieces of Direct-Current Dynamos.* **R. V. Picou.** (Ind. Élect. 10. pp. 493-495, Nov. 10, 1901.)—The principal losses due to eddy currents in direct-current dynamos occur in the bolts for holding together the core disks, and also in the polar faces when the armature has open slots. The losses due to this latter cause are discussed in this paper. Periodic variations of high frequency in the magnetic flux at the polar faces are caused by the teeth of the armature, and calculations are made to try and find the magnitude of this effect. The eddy currents in that part of the polar face opposite a tooth of the armature tend to demagnetise the field, whilst the eddy currents opposite a slot tend to magnetise it. The resultant demagnetising action is proportional to the difference between these two effects. The author discusses what is the probable phase-difference between the eddy currents and the e.m.f.'s giving rise to them. Seeing that the pole-pieces are massive, this phase-difference is probably very large, although the effect of the high frequency is to confine the eddy currents to a thin layer on the surface of the iron. He calculates the eddy current losses on the pole-pieces of a four-pole 70-kw. machine making 600 revs. per min., and having

55 slots on a drum armature whose diameter is 50 cm. The maximum flux is 816,000 maxwells and the minimum 224,000 maxwells, the air-gap being 2 mm. He shows that the demagnetising action of these currents can be neglected, and by making certain assumptions he calculates that the power dissipated by them is 191 watts. If the polar faces had been covered by a sheet of copper 1 millimetre thick, the eddy currents which would be localised in it would give exactly the same loss. The author thinks that the loss due to eddies would probably be greater than 191 watts, and points out that if it were much greater then it would be advantageous to cover the polar faces with thin sheets of copper. It is ordinarily assumed that the eddy current loss is proportional to the square of the angular velocity. This is only true when the eddy currents are in phase with the e.m.f.'s producing them. If the phase-difference is large the losses are almost directly proportional to the velocity. Hence methods of separation of the losses due to eddies and hysteresis, based on measurements at different speeds, are inaccurate. A. R.

190. *Sparkless Collection*. C. W. Hill. (Elect. Rev. 49, pp. 462-468, Sept. 20, 1901.)—The author comments on H. A. Mavor's paper (*l.c.* pp. 489-490). Mr. Mavor says the ampere-turns on the armature producing cross-turn reaction should not exceed 25,400 per inch length of the space; then if the ratio of e , the average e.m.f. per section of armature to r , the reaction voltage of a section undergoing commutation is not less than 2, the machine will be sparkless. The author gives a different expression $\frac{A - A_1}{A_2}$ where A = total ampere-turns in gap, A_1 = armature reaction expressed in ampere-turns, A_2 = magnetising ampere-turns in that portion of the armature which is undergoing commutation, and says that $\frac{A - A_1}{A_2}$ should

be of such a value that $\frac{e}{r}$ would be equal to 2. This, however, is not sufficient to prevent sparking. He gives an example where $\frac{e}{r} = 4.8$, and yet there was slight sparking. Other magnetic conditions, such as the number and density of teeth, &c., must receive careful consideration. R. B. R.

191. *Air-gap Induction*. F. W. Carter. (Elect. World and Engineer, 38, pp. 884-888, Nov. 30, 1901.)—The author begins with a brief *résumé* of a previous paper [see Abstract No. 2101 (1900)]; he then solves an ideal problem, so devised as to resemble very nearly that of the magnetic flux between a smooth pole-face and a slotted armature. His solution shows that few lines of force penetrate far into the slot, so that, unless it is very shallow, which is not the usual case, the depth has little effect. Formulae and diagrams are given by which the effect of the slot can be calculated. He also shows how to allow for the effect of an internal ventilating duct. The following formula enables the eddy loss in the pole-faces to be calculated when the amplitude of the variation of the flux is known:—

$$P = 8B^2 D^2 \mu^{-\frac{1}{2}} s^{-\frac{1}{2}} 10^{-13},$$

where P is the loss per square inch of pole-face in watts, B is the amplitude of the variation in lines per square inch, D is the diameter of the armature in inches, n the speed in r.p.m., s the number of slots in the armature, and μ the permeability of the iron of the pole-face for the induction at which it is being

worked. Formulæ are given to determine B approximately. He suggests a method of mapping out the magnetic field in an air-gap by finding, in the ordinary laboratory manner, the lines of flow on a plate cut in a particular shape through which current is flowing. The solution of an ideal case by the method of conjugate functions is given, and illustrates how complicated the exact solution of the problem is. A. R.

192. The Inductor Alternator. E. Heitmann. (Elect. World and Engineer, 38, pp. 548-549, Oct. 5; 594-596, Oct. 12; and pp. 686-688, Oct. 19, 1901.)—The electrical and magnetic features of the inductor alternator are considered in detail. It is pointed out that the direction of magnetisation is never completely reversed, as it is in other types of alternators, but merely increases from zero to a maximum value, and again decreases to zero with a nearly constant direction. Upon this fact depends, to a large extent, the economical design and good operation of inductor alternators. Owing to the incompleteness of the cycle, very high-line densities can be employed without bringing the iron losses up to those found in other types. Working the teeth at such high-line densities, viz., on the top of the saturation curve, gives improved regulation. The leakage around the slot is inversely proportional to the reluctance of the path, and the fact that the teeth are worked at high-line densities in inductor alternators therefore makes the reluctance of this path very great. The winding is of the style generally known as a concentrated winding, usually one slot per pole per phase, and an approximation to a sine curve is obtained by shaping away the pole surface so as to vary the air-gap density. Details of design curves and other data are given of various inductor alternators associated with the names of Stanley, Kelly and Chesney.

For a 500 kw., 2,500 volts, 60 $\sim$, machine, at a speed of 100 r.p.m., the following figures are given:—

Power-factor.	Regulation.	Field Current.
100 per cent.	5.6 per cent.	85 amperes
90 "	10.5 "	100 "
80 "	11.6 "	105 "
70 "	13.0 "	110 "

The no-load field current is 79 amperes, and the increase in field current from no-load to full load at 70 per cent. power-factor is about 40 per cent.

The efficiencies are:—

Per Cent. Load.	Per Cent. Efficiency.
125	94.0
100	93.8
75	92.7
50	91.0
25	86.0

A turbine-driven machine 2,000 kw. 2,200 volts 60 $\sim$ 240 revs. gave the following figures:—

Power-factor.	Regulation.	Field Current.
100	8.0	154
90	8.2	174
80	11.0	180
70	11.4	187

The no-load field current is 146 amperes at 2,500 volts, and thus the increase

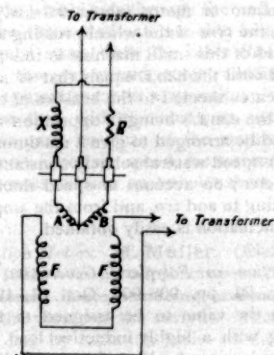
in field current from no-load to full load on a 70 per cent. power-factor is about 80 per cent. The efficiencies are :—

Per Cent. Load.	Per Cent. Efficiency.
125	95.0
100	94.7
75	98.5
50	92.0
25	89.0

E. K. S.

193. *A New Synchroniser.* **F. P. Woodbury.** (Amer. Electn. 13, pp. 527-528, Nov., 1901.)—An instrument devised by P. M. Lincoln to indicate not only when two machines are in synchronism, but to show which machine is running the faster. In shape and size the instrument resembles a two-pole fan motor, but with a dial and pointer in place of the fan and guard. The field magnet is laminated, and the rotor is an ordinary armature core with two coils wound, practically, at right angles to each other, and connected as shown in the diagram.

A and B are armature coils ; F, F the two magnet limbs, R a non-induc-



DIAGRAMS OF CONNECTIONS

tive resistance in the form of an incandescent lamp ; X an inductance coil. The latter can be adjusted by altering the air-gaps so as to produce a difference of phase of 90° between the currents in the two coils A and B. The self-induction in the stator coils FF produces a lag of about 90° . When the current in coil A is in phase with the current in the stator winding FF, that in coil B is 90° out of phase with it. Coil A, therefore, sets itself at right angles to the field, and the pointer stands vertically and indicates synchronism. When the current in coil B is in phase with the stator current, B will lie at right angles to the field, throwing the pointer into the horizontal position, either to the right or left, according to which machine is leading.

When the machines are in direct opposition the pointer stands vertically, but points downwards. Intermediate phase conditions produce intermediate positions of the pointer. The foregoing assumes both machines to be running at the same speed. A difference between the speeds of the two machines causes the pointer to rotate backwards or forwards, according to whether the machine being synchronised is running slower or faster than the other. F. B.

194. Parallel Running of Alternators. **H. S. Meyer.** (*Elektrotechn. Zeitschr.* 22. pp. 905-908, Oct. 31, 1901.)—The author sums up the reasons which have led to the practical importance of this problem as follows:—(1) The fact that for the generation and distribution over extended areas of large amounts of power, polyphase currents are preferable to continuous ones; (2) the tendency towards the adoption of the largest possible generating units; (3) the almost universally established practice of coupling the generators direct to the prime movers; (4) the combination of continuous-current distribution with alternating-current generation, by the use of rotary converters. The problem of parallel running is next discussed in detail. Irregularities in the angular velocity of the generators are considered under two heads:—(1) Those due to the hunting of the prime-mover governors—this evil may be remedied by the use of properly designed oil dash-pots; (2) those arising from the periodic fluctuations in the driving torque during each complete revolution of the engine. In connection with these latter the author gives the complete theory of flywheel design. The paper concludes with a description of an ingenious electrical method, devised by the engineers of the General Electric Company, for determining the speed fluctuations. A small continuous-current dynamo or motor (about 0.5 kw.) has a bicycle wheel mounted on its spindle, the tyre of the wheel pressing against the flywheel of the generator. The field of this small machine is independently excited, and the excitation is varied until the e.m.f. equals that of a battery of secondary cells. The latter is then connected to the brushes of the dynamo through a low-reading voltmeter, the e.m.f.'s being in opposition (if each e.m.f. is about 100, the voltmeter would be arranged to give a maximum reading of, say, two volts). If the generator speed were absolutely constant, no reading would be obtained on the voltmeter; on account of speed fluctuations, however, the voltmeter is kept vibrating to and fro, and from the amplitude of its readings the percentage speed fluctuation is easily obtained. **A. H.**

195. Armature Reaction in Polyphase Generators. **K. Pichelmayer.** (*Elektrotechn. Zeitschr.* 22. pp. 908-909, Oct. 31, 1901.)—This paper is mainly concerned with the value to be assigned to the back-turns of the armature when dealing with a highly inductive load. The author recommends the use of a formula given by Kapp for a sine distribution of flux, and for the typical flat-topped wave of flux gives a table of values of the corresponding constant for various types of winding. The amount of inductive drop in an armature may be roughly ascertained experimentally by removing the field-magnet flywheel and measuring the p.d. required to maintain the full-load current through the armature. **A. H.**

196. Bouchérot's Three-phase Induction Motors. **H. Luraschi.** (*Elettricità, Milan*, 20. pp. 598-601, Sept. 21; and pp. 611-614, Sept. 28, 1901.)—The author describes the induction motors made by the Société Anonyme des Applications de l'Électricité under Bouchérot's patents. The novel feature in the motors is the insertion of resistance in the rotor without the use of brushes. The rotor has the ordinary squirrel-cage winding, with a ring short-circuiting the bars at each end. In the middle, however, the bars are again connected together, but by strips of resistance material. The stator is composed of two separate and similar parts, each a complete stator acting on one half of the rotor, and arranged to turn one relatively to the other, round the axis of the motor. When the two portions are in their normal position, with poles of like sign adjacent, the rotor currents flow round the squirrel-

cage without passing through the resistance ring. If, however, the stators be displaced, they induce currents in any one rotor bar which are in opposition, more or less according to the amount of displacement; the resistance ring then forms part of the rotor circuit, and its effect is greater the greater the displacement of the stators. The motor then is started with the stators displaced so as to have poles of opposite signs adjacent, when the whole rotor current must pass through the resistance ring; the stators are gradually moved back to their normal position, which has the effect of cutting out the rotor resistance, by making the current take other paths. In large motors this displacement of the stators becomes mechanically difficult, and the inventor then puts two windings on a single solid stator, and displaces the phase of the current in the two windings by a phase-transformer. G. H. B.

197. *Automatic Starter for Asynchronous Polyphase Motors.* (Ind. Elect. 10, pp. 457-458, Oct. 10, 1901.)—A cylindrical box, made of some insulating material, and divided, for a three-phase motor, into three compartments, by insulating partitions of which the planes are parallel to the ends of the box, is mounted coaxially on the spindle of the motor. In each compartment are fixed two metal studs, which pass through the wall of the box at opposite ends of a diameter, the three studs at one side being connected together outside the box by a metal strap, while the other three are connected to the points of junction of the star-wound rotor windings and the starting resistances. In each compartment is a quantity of mercury, the amount of which is adjusted so that, with the motor at rest in any position, one at least of the contacts must be clear of the mercury. When the motor is started and has attained a certain speed, the mercury, under the influence of centrifugal force, spreads out into an annular sheet, and short-circuits the starting resistances. B. P. S.

198. *Rating of Traction Motors.* M. Müller. (Elektrotechn. Zeitschr. 22, pp. 921-924, Nov. 7, 1901.)—As an approximation, the author neglects the hysteresis and eddy-current losses occurring in a motor, and assumes that the total loss varies as the square of the current. Assuming further that the rate at which heat is lost by radiation varies as the temperature rise, and equating the difference between the rate of gaining and losing heat to the rate at which heat is accumulating in the coils (= thermal capacity $\times$ rate of temperature rise), the author obtains a differential equation whose solution is—

$$r = \frac{i^2}{b} \left(1 - e^{-\frac{t}{a}} \right) + r_0 e^{-\frac{t}{a}}$$

where r = temperature at time t ; r_0 = initial temperature; i = current, and a and b are constants. In order to determine a and b experimentally, we note the values of r after any convenient interval from the time of starting, and again when r has become steady ($t = \infty$); the latter reading gives $b = i^2/b$, and the former enables us then to calculate a . The author uses this formula to study the heating of a motor under given conditions of service; and shows that with a variable current the mean square value of the current, when substituted in the above equation, gives results sufficiently near the truth. He draws special attention to the extreme slowness with which the motor cools down after having been used, the law of cooling being $r = r_0 e^{-\frac{t}{a}}$. A. H.

199. *High-speed Railway Motors with Phase Compensation.* A. Heyland. (Elektrotechn. Zeitschr. 22, pp. 924-925, Nov. 7, 1901.)—With reference to a recently described induction motor for a high-speed railway, the author points out the advantages which would result from the adoption of his method of making the power-factor equal to unity [see Abstract No. 2475 (1901)]. The no-load current would be reduced from 50 to 3 amperes, no change of connections would be required when starting under an overload of three times the normal load, the power-factor would be much higher under all conditions of working, and a powerful braking effect could be obtained by a single change of connections, and without the use of a battery of secondary cells such as was required in the case of the motor referred to.

A. H.

200. *Transformers.* A. S. M'Allister. (Amer. Electn. 18, pp. 471-474, Oct., 1901.)—In this paper the author discusses the elementary theory of the alternate-current transformer, explaining the various reactions and phase-relations both in the ideal transformer and under normal working conditions. The distortion of the magnetising current is due to the increase of reluctance of the magnetic circuit through saturation, which demands at maximum magnetisation a larger current than would have been required for a reluctance of the core equal to that at low magnetic density, thus causing the exciting current wave to be peaked. Hysteresis causes the current wave to reach its zero value sooner than otherwise. With regard to regulation, just as a lagging secondary current drawn through a reactance causes a drop at the receiving end, so a leading current of equal value through the same reactance may cause an actual increase in the apparent receiver voltage.

B. P. S.

201. *Leakage Drop in Transformers.* O. S. Bragstad. (Elektrotechn. Zeitschr. 22, pp. 821-824, Oct. 8, 1901.)—The total drop in a loaded transformer may be regarded as made up of the resistance drop and the reactance drop, the former being in phase, and the latter in quadrature, with the current. After giving an elegant graphical construction for predetermining the drop when the primary p.d. is constant, or the primary p.d. when the secondary p.d. is constant, the author discusses the experimental determination of the equivalent resistance and inductance of a loaded transformer. One such method is the well-known one due to Kapp, in which the secondary is short-circuited. The author has devised the following highly ingenious method, which he calls the "method of opposition," and which may be applied to a transformer which is at work, provided another precisely similar transformer is available. An ammeter and the current coil of a suitable wattmeter are included in the secondary circuit of the loaded transformer. The primary of the unloaded auxiliary transformer is joined across the primary mains, in parallel with that of the first transformer, one end of whose secondary is connected to one end of the secondary of the auxiliary transformer, the connection being made so that the secondary e.m.f.'s are in opposition. A voltmeter is next connected to the free ends of the secondaries. This will give the total impedance drop in the loaded transformer. Lastly, by joining the free ends of the secondaries across the pressure coil of the wattmeter, the total power lost by heating of the coils is found, and from this the resistance drop component is immediately obtained. Some numerical results are given to show how consistent are the values which may be obtained by means of this method.

A. H.

202. *Stable Running of Rotary Converters.* M. Leblanc. (Comptes Rendus, 188, pp. 679-681, Oct. 28, 1901.)—Two cases are described in which the armature of a rotary converter, at certain loads, becomes dynamically unstable, and, instead of maintaining a constant speed, takes up a pendulum movement, the speed accelerating and retarding in turn between limits depending on the load. (1) In the first case the converter was arranged to transform from direct current (supplied from a secondary battery, from which also the fields were excited) to three-phase alternating, which was transformed first up and then down, and finally absorbed by a rheostat. As the load was gradually increased, the oscillations began, becoming finally very considerable. The explanation given is the demagnetising effect of the three-phase wattless currents, which, beyond a certain limiting load, are increased by any accidental increase of speed. This is explained by the form of the expression which represents the current I as a function of the speed ω and of the load; $dI/d\omega$ begins by being negative, but at a certain "limiting load" passes through zero and changes sign. The increase of current in the armature weakens the field and causes the machine to run still faster. The "limiting load" should therefore be greater than the maximum load which the machine is intended to give. Lowering the frequency of the generated alternating currents, and diminishing the coefficients of induction and magnetic leakage of the transformers, increases the limiting load. (2) In the other case, a rotary converter was connected to alternating mains, and worked perfectly up to full load. When, however, an alternating booster, with large magnetic leakage, was put in the primary circuit in order to regulate the pressure of the direct current generated, as soon as half load was reached the oscillations of the armature began. This is explained as follows: With a constant field, excited by secondary batteries, and an alternating terminal p.d., of constant r.m.s. value, an increase of speed is accompanied by a diminution of torque. But an increase of p.d. involves an increase of torque. At small loads the first effect predominates; but as the load increases a point is reached where increase of speed is accompanied by increase of torque, and the machine accelerates until the torque ceases to increase. Being then in unstable dynamic equilibrium, it begins to slow down. A remedy is to wind the inductor circuit with two windings, one a magnetising coil in shunt across the brushes supplying the direct current, the other, a demagnetising coil, in series with the generated current. The machine then works as well with a booster in the alternating circuit as if connected direct to the mains.

B. P. S.

203. *Motor-Generators v. Rotary Converters.* (Electrician, 47, pp. 985-987, Oct. 18, 1901.)—This article is substantially a communication from the Oerlikon Company, who have lately tested motor-generators, both of the synchronous and asynchronous types. An elaborate series of curves is given, showing the characteristics of the various machines, and a comparison is made between rotary converters and motor-generators, from which it would appear that the efficiency of motor-generators is not less, but, if anything, rather greater than that of rotary converters. The synchronous motor-generator was for 50-cycle current at 8,500 volts, and was coupled direct to an 8-pole continuous current dynamo for an output of 1,350 amperes at 260 volts at 875 r.p.m. The induction motor was for 6,000 volts and 50 cycles, and was coupled direct to a 4-pole dynamo giving 510 amperes at 450 volts at 370 r.p.m. The performances of these machines are contrasted with those

of rotary converters of another make, having somewhat similar outputs. The results are summarised in the following table :—

	Oerlikon Co.'s synchronous motor-generator of 350-kw. capacity.			Oerlikon Co.'s asynchronous motor-generator of 350-kw. capacity.			Static transformer and rotary con- verter of 350-kw. capacity.			Static transformer and rotary con- verter of 500-kw. capacity.		
	Motor.	Gene- rator.	Total.	Motor.	Gene- rator.	Total.	Trans- former.	Con- verter.	Total.	Trans- former.	Con- verter.	Total.
Weight in Tons. ...	12	11	23	8	9.5	17.5	4.65	8	12.65	6.9	14.5	21.4
Efficiency { full load	96	95	91	94.5	95	90	96.6	92.7	89.5	97	93.2	90.5
$\frac{1}{2}$ load	93	92.5	87	93	92.6	86	95.2	89.2	85	95.8	89.5	85.5
$\frac{1}{4}$ load	88	90	80	89	88	78	—	—	—	—	—	—

The article points out that if the decision depends on the merits of simplicity of starting manipulation, upon the safety of service in case of interruption to the line, and the absence of tendency to hunting on the part of the generators, the induction-motor system is by far the most advantageous, and this system would seem, in general, to be preferred by the Oerlikon firm. The pros and cons of the various systems are concisely discussed.

H. S. Meyer criticises the figures and statements made in the above article. (See *Electrician*, Nov. 1, 1901.) He points out that the question of cost is altogether disregarded, and that, from this point of view, the rotary converter combination is far the best. He also considers that the Oerlikon Company has rather understated the efficiency of rotary converters. **W. H. S.**

REFERENCES.

204. Compound Alternators on the Hutin and Leblanc System. J. Routin. (International Electrical Congress at Paris, Reports, pp. 137-154, 1901.)—This paper is on similar lines to the one dealt with in Abstract No. 2100, 1900. **G. W. DE T.**

205. Alternating Currents obtained from Continuous-Current Armatures. F. Eichberg. (*Elektrotechn. Zeitschr.* 22, pp. 563-564, July 11, 1901. Paper read before the Verband Deutsch. Elektrotechn. at Dresden, 1901.)—The author considers a number of arrangements in which certain points in the winding are connected to an auto-transformer, by means of which three-phase alternating p.d.'s may be obtained, the amplitudes of which exceed the value of the continuous e.m.f. **A. H.**

206. The Regulation of Alternating-Current Generators. A. S. M'Allister. (*Amer. Electn.* 13, pp. 392-394, Aug., 1901.)—The regulation of an alternating-current generator is defined as the percentage increase in terminal e.m.f. when the full-load current of specified power-factor is thrown off, the speed and excitation remaining the same. A clear discussion, with instructive diagrams, is given of how the regulation depends on the number of phases and the character of the load on each phase. **A. R.**

207. The Graphical Theory of Synchronous Motors. P. M. Verhoeckx and A. Blondel. (*Ecl. Electr.* 29, pp. 131-133, Oct. 26, 1901.)—Letters from Verhoeckx and Blondel discussing the relative merits of their graphical constructions for determining the "Wattless" current of a synchronous motor when the "watt" current is constant. [See further Abstracts Nos. 2476 and 2010 (1901).] **A. R.**

ELECTRICAL DISTRIBUTION, TRACTION AND LIGHTING.

ELECTRICAL DISTRIBUTION.

208. Erection of Overhead Power Lines. Loppé. (Soc. Int. Élect., Bull. 1. pp. 455-484, Aug., Sept., Oct., 1901.)—The author considers, in the first place, the effect of variations of temperature in causing both elongation and change of elasticity, giving formulæ and tables for determining—(1) the length of the wires in times of the sag and the span; (2) the change of sag of copper wires, firstly, in times of the temperature change, of the initial sag, and of the initial tension; and, secondly, in times of the change of pressure per metre run, of the initial sag, and of the initial tension. The effect on the impedance of the line, of the distances between the wires, is then discussed, and tables are given, due to Blondel, which were originally published in 1894 in "l'Éclairage électrique;" after which the author proceeds to consider the principles determining the best length of span under given circumstances, and tables are given to facilitate the evaluation of the formulæ for wires of copper and aluminium, allowing for a wind pressure of 125 kg. per square metre of superficial area of the wires. This pressure will be about 0.60 of that on a plane surface.

Increase of span involves, *ceteris paribus*, a corresponding increase of sag, which is limited by the greatest admissible height of the poles, and, on account of the necessity of preventing contact, by the distance between the wires. In American practice the sag is not allowed to exceed double the latter distance, but the author states that no trouble has arisen from this cause in the case of the Paris and Bordeaux telephone line, consisting of a pair of wires 4.5 mm. in diameter, separated by an interval of 0.65 metre, and having spans of from 70 to 80 metres, and therefore a sag exceeding 2 metres. The author, as an example, gives in detail the calculations for a three-wire three-phase line of copper-wire 5 mm. in diameter, with a maximum allowable tension of 8 kg. per sq. mm., and under given conditions as to maximum wind pressure, temperature limits, and possible accumulation of snow or ice. The necessity is insisted on of diminishing the tension at which the wires are erected, when, owing to crossing other lines, or for any other reason, the span has to be decreased, and advises its decrease in the same ratio as that of the span. In conclusion, the author discusses, by the aid of tables of the mechanical and electrical constants of copper, aluminium, and various kinds of bronze, the relative advantages of these materials for overhead line wires. With copper costing, as at present, 2 fr. 20 per kg., and aluminium 4 fr. per kg., it is shown that both the best length of span and the cost will be about the same, whichever material be employed. With regard to dissipation of heat, aluminum is at a disadvantage compared with copper, but the use of bronze is strongly advocated in preference to either, even for wires of large diameter. G. W. DE T.

209. Composite Metal Span-Wire Poles. (Street Rly. Rev. 11. pp. 795-796, Oct., 1901.)—The average life of wooden poles is about eleven years, and of metal poles about thirty-three years. A number of wooden poles would cost for thirty-three years about \$8,500, while pipe-poles in the same period would

cost only \$2,500. A system of composite iron poles has been devised by J. Lanz, of Pittsburgh, which includes tubular-poles built up of plates and channel iron. A description of these, with illustrations, is given in the article. Plain I beams are advocated in some cases, and it is pointed out that a 9-inch I beam pole of 21 lbs. per foot weight, loaded in the direction of the web, is equal in strength to an 8-inch pipe, the weights being respectively 680 and 1,220 lbs. for 80-foot lengths.

E. K. S.

210. *Poles of Armoured Cement.* **E. Barni.** (Elettricità, Milan, 20. pp. 647-648, Oct. 12, 1901.)—The paper describes poles constructed by the author, consisting of two H girders, fixed together by bolts and distance pieces to present a section II , the distance between them being, at the top, 14 cm., and at the bottom 50 cm. A short length of wood is fixed between the girders at the top, and projects above them, to carry the insulators. The space between the girders is then filled with rubble cement. The author's experience with these poles has been satisfactory; their cost, for a height of ten metres above the ground, is 120 francs.

G. H. B.

211. *Heating of Electric Conductors.* **W. Weiler.** (Elekt. Runds. 19. pp. 42-43, Nov. 15, 1901.)—The author considers the question of determining the temperature finally reached by a bare conductor carrying a given current, and arrives at the formulæ—

$$i = \frac{\pi d}{2} \sqrt{\frac{kd + 0.000557t}{\rho(1 + \alpha t)}}$$

and—

$$k = 0.05625(1.0077)^\theta(1.0077^t - 1),$$

where i = current, d = diameter of wire in centimetres t = excess of final temperature over that of the atmosphere, θ = temperature of the atmosphere, ρ = specific resistance of the metal, α = temperature coefficient, and k = watts dissipated per sq. cm. of exposed surface of the wire. A diagram is given from which it is possible to ascertain the rise of temperature in copper wires of from 0.1 to 12 mm. in diameter, and carrying currents which range up to 400 amperes.

W. H. S.

212. *Wiring Rules.* **C. H. Wordingham.** (Electrician, 48. pp. 84-85, Nov. 8, 1901.)—While it is impossible to draw up a set of rules to cover every case, there are certain conditions common to all cases which should be rigorously fulfilled. These may be codified, when necessary, and supplemented in each case by a detailed specification. The rules should be devised to guide competent workmen, not to teach incompetent men. Fittings should be tested by an independent central authority, and those types which are found satisfactory should be officially registered.

Supply rules are totally distinct from wiring rules, and should contain, in addition to the general conditions of supply, regulations for the prevention of disturbance of other consumers by leakage and sudden changes of load, and the prevention of shock. All such rules should be confined to matters essential to the provision of a satisfactory supply to all classes of consumer.

A. H. A.

213. *Wiring Rules.* **Budde.** (Elektrotechn. Zeitschr. 22. pp. 972-977, Nov. 21, 1901. Paper read before the Verband Deutscher Elektrotech-

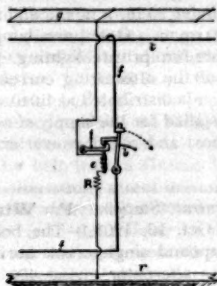
niker.)—The wiring rules adopted by the Verband Deutscher Elektrotechniker are here given in so far as they apply to low tension installations. These are defined to be those in which the voltage between two cables insulated from earth does not exceed 500, or in which the voltage between an insulated and earthed cable does not exceed 250. An appendix contains the standards laid down for the various sizes of cables and their insulation.

W. H. S.

214. Duplicate Feeders. **L. Andrews.** (Elect. Engin. 28, pp. 682-683, Nov. 1, 1901.)—The author refers to a paper in which he described a system of duplicate feeders with discriminating cut-outs [see Abstract No. 1289 (1898)], and describes a case at Hastings in which a feeder broke down, but by the operation of the cut-out, the faulty feeder was disconnected, and the supply maintained without interruption through the duplicate feeder.

A. H. A.

215. Trolley Wire Protection in Santiago de Chile. (Elect. Rev. 49, pp. 502-503, Sept. 27, 1901.)—As there had been several accidents by telephone wires coming in contact with trolley wires the Santiago Municipality appointed a committee to report on the various protective devices. The committee decided that the only effective system was to earth the guard wire to the rail, but the traction company objected that its poles would not carry the extra weight of the



heavy guard wires, and also that the whole system would be subjected to a severe shock in case of accident. Salazar therefore devised the arrangement shown in the sketch, which has the following advantages: 1. Certainty of action with a predetermined current. 2. The low conductivity and small sectional area required in the guard wire. 3. Independence between the circuit breaker and main feeder. 4. The fact that the arrangement does not operate by excess of current, so that neither fuses nor cables are affected by an accident. 5. The absence of fuses to be replaced, enabling the circuit to be remade by merely restoring the breaking lever to its normal position.

E. K. S.

ELECTRICITY WORKS AND TRACTION SYSTEMS.

216. San Paulo (Brazil) Electricity Works. (Street Rly. Journ. 18, pp. 167-174, Sept., 1901.)—The station is driven by water-power, being situated at Parnahyba, 21 miles from San Paulo. It contains three 1,000-kw. three-

phase alternators, direct-coupled to turbines running at 200 r.p.m. The power is generated at a pressure of 2,800 volts, and is then transformed to a pressure of 24,000 volts for transmission to San Paulo. Current is distributed both for lighting and traction, the tramway generators being driven by induction motors, and the lighting carried out by alternate current.

W. H. S.

217. *Central Power Station of Birmingham, Ala., U.S.A.* J. R. Williams. (Amer. Electn. 18. pp. 421-424, Sept., 1901.)—System: Three-wire direct current at 125 volts, and series arcs for lighting; direct current at 500 volts for traction; single-phase and monocyclic alternating current for supplying the remoter districts. The boiler-rooms contain 24 horizontal return-tube boilers, working at 120 lbs. per square inch, and feeding a single wrought-iron header 14 inches in diameter. The feed-water is heated by Wainwright heaters. The furnaces are fired by hand. The engine-room contains 10 simple non-condensing Corliss engines and one single-valve automatic engine; fuel is so cheap that compound condensing engines offer no prospects of economy. Six of the engines are coupled in pairs; two of these sets have cylinders 24 in. $\times$ 48 in., and drive two 875-kw. railway generators at a speed of 82 r.p.m.; the third set has cylinders 20 in. $\times$ 30 in. and drives two 200-kw. lighting generators, working at 125 volts each, at 150 r.p.m. Four other engines have cylinders 21 in. $\times$ 48 in., 18 in. $\times$ 42 in., and 26 in. $\times$ 48 in. respectively, and drive various generators by means of counter-shafting. The automatic engine has a cylinder 20 in. $\times$ 20 in., and drives direct two 100-kw. 125-volt dynamos at 200 r.p.m. Open arc lamps are used for public lighting, and enclosed arcs for private lighting. For the supply of the neighbouring towns, part of the alternating current is transformed up and transmitted at 5,000 volts; it is distributed at 1,040 volts. A 5,000-volt three-phase alternator is to be installed for the supply of a railway line to Bessemer, 12 miles distant; transformers and rotary converters will be installed in substations for this purpose.

A. H. A.

218. *The Karlsruhe Central Station.* F. Winawer. (Elektrotechn. Zeitschr. 22. pp. 847-853, Oct. 10, 1901.)—The boilers are by Steinmüller and the three tandem compound single-crank horizontal engines by Kuhn, each driving a three-phase alternator giving 400 kw. at 4,000 volts and 50 $\sim$, with 66 poles and 91 r.p.m. The paper contains a fairly good description of the cable system and transformer substations. It contains eight good illustrations.

E. K. S.

219. *Longton Electricity Works.* (Elect. Engin. 28. pp. 546-549, Oct. 18, 1901.)—A description is given of this station, which contains two 145-kw. dynamos, and a battery of cells, giving 40 kw. for 10 hours.

W. H. S.

220. *Battersea Electricity Works.* (Elect. Engin. 28. pp. 510-516, Oct. 11, 1901.)—This continuous-current station contains four Babcock boilers, each evaporating 11,000 lbs. of water per hour, fitted with chain-grate stokers, the feed-water being heated by an economiser of 256 tubes. The main steam ring has an internal diameter of 11 inches. The plant includes one 400-kw. and two 200-kw. machines, and two steam-driven balancers, the dynamos of which have an output of 46 kw. each. The steam is condensed by ejector condensers. A diagram is given showing the connections on the switchboard, and various interlocking and safety devices are illustrated and described.

The battery-room contains 280 cells, having an output of 100 kw. for five hours. Five feeders have been laid, all of which consist of concentric cables, the conductors having a sectional area of 0.5 square inches. A middle-wire connection is also brought back to the station from two points in the distributing network, the cables laid for this purpose having sectional areas of 0.25 and 0.5 square inch respectively. Street lighting is carried out by means of 240 arc lamps, taking 10 amperes each; they are connected 10 in series across the 460-volt mains. The article contains several drawings showing the arrangements in the station.

W. H. S.

221. *Remodelled Plant of the Georgia Electric Light Company.* (Amer. Electn. 18, pp. 465-471, Oct., 1901.)—The old plant of the Georgia Electric Light Company, organised in 1890, has lately been dismantled, and the station and plant brought up to date. A large number of small generating sets has been replaced by the following equipment:—Two General Electric three-phase alternators each of 1,000 kw. capacity, and one of 600 kw., generating at 2,500 volts and 60 periods; of these the two larger machines are direct driven by two Rice and Sargent cross-compound engines, and the smaller, through a 48-inch belt, by a Greene engine of similar type; one 600 volt General Electric railway generator, of 700-kw. capacity, direct driven by a McIntosh and Seymour tandem compound engine; and a Harris-Corliss tandem compound engine, driving through a counter-shaft several railway generators which have been retained from the old equipment. There are eight Babcock and Wilcox boilers rated at 250 h.p. each, and two rated at 325 h.p. each. Coal is delivered direct from the trucks into bins in the boiler-room. Steam-pipes are all in duplicate. The engines run condensing: a central condenser of 5,000 h.p., two triple expansion duplex circulating pumps, and a "dry vacuum" air-pump, all of the Worthington type, are installed. Green economisers are used, and a Webster open heater. There are also a 200-kw. General Electric and a 100-kw. Short railway generator, both driven by belt from a Greene tandem compound engine; a 50-kw. exciter for the alternators, direct driven by a Straight Line simple engine, and another exciter driven by a 35-kw. induction motor.

The distribution, apart from the railway service, is on two systems, one area being supplied with alternating current direct from the primary three-phase bus-bars, and another with direct current from a substation with rotary converters fed from the same bus-bars. The direct-current generators in the main station, which supply the railway service, are reinforced by a Westinghouse rotary converter of 300-kw. capacity. In the district of alternating supply about 650 enclosed arc lamps are run in series through constant-current transformers in the main station; these circuits also comprise about 450 series incandescent lamps of 75 c.p. each. The alternating current primary distribution is by lines carried on poles, the pressure being reduced by transformers to 115 volts at suitable intervals. The substation is provided with a battery of 150 chloride accumulators with a one-hour discharge rate of 2,720 amperes at a minimum e.m.f. of 240 volts; three 400-kw. General Electric two-phase rotary converters; six 250-kw. three-phase to two-phase General Electric air-blast transformers, and the necessary switchboard equipment. By means of dial switches operated by small direct-current motor, the secondary e.m.f. of the transformers can be varied from 160 to 240 volts, and therefore the direct-current voltage of the converters, which are connected across the outer bus-bars of the three-wire distribution, from 240 to 360 volts. The motors which operate the dial switches

are worked in either direction by double pole reversing switches. The neutral bus-bar is connected through switches to the middle of the secondary winding of the transformers. The arrangement of the underground distribution is described, but calls for no special remark. The change over was made from the old plant to its present form without a single shut-down at the station, and without discontinuing any customer's service for more than an hour and a half. The paper is well illustrated with photographic blocks and diagrams of connections. B. P. S.

222. *Malakoff (Seine) Electricity Works. C. Dantin.* (Génie Civil, 89, pp. 861-865, Oct. 5, 1901.)—These works are intended to supply current for a tramway system of a total length of about 40 kilometres within and without Paris. Inside the city the cars are run by means of accumulators, which are charged through a trolley from aerial cables erected along the parts of the routes which lie outside the walls, the cars being run from the overhead supply while the cells are being charged. The general construction of the station and of the lines has been carried out by the French Thomson-Houston Company. There are six Babcock and Wilcox boilers, arranged in pairs, working at 11 kg. per sq. cm., and each capable of evaporating 2,900 kg. of water per hour, or 8,100 under forced draught. There is also a Green's economiser of 400 square metres heating surface; two Worthington feed-pumps, each capable of supplying the whole of the boilers, and an electrically worked pump, of the "Thirion" type, of similar capacity. There are in present use two direct-coupled steam sets, each of 500-kw. capacity, and a third is to be shortly erected. The generators are 8-pole, compound-wound machines, of which the full rated load is 910 amperes at 550 volts; they were built by the Société des Établissements Postel-Vinay. They present no special features of interest. They are stated to be capable of working for 24 hours continuously on full load with a rise of temperature not exceeding 50° C. for any part of the machine, and, after this, an overload of 50 per cent. for 1 hour with a rise of not more than 60° C. The efficiencies given are:—One-quarter load, 89·7 per cent.; half-load, 92·8 per cent.; three-quarter load, 93·8 per cent.; full load, 94 per cent.; 50 per cent. overload, 93 per cent. The engines are of the "Allis" type, built by the Société française des Constructions mécaniques. They are of the horizontal, compound, condensing type, with Reynolds-Corliss valve gear, running at a mean speed of 95 r.p.m. The diameters of the cylinders are 508 and 1,016 mm. respectively, the stroke being 1,220 mm. The connecting rods are of exceptional length, being six times the crank radius. Each engine is provided with two Porter governors, one of which regulates the steam admission to each cylinder simultaneously; the speed of the engine can be varied while running by an adjustment of this governor. The other is a safety device to cut off steam if the engine should run away. The flywheels are 6·1 metres external diameter, and weighs 40 tons (French) each. Figures are given of a 6-hours full load test in which the steam consumption came out at 6·26 kg. per indicated horse power hour (French). In addition to the main engines and generators, there is a small vertical high speed set of 70 kw. for works, lighting, &c., which can also be used, if necessary, to excite the large generators. The switchboard consists of nine marble panels in an angle-iron frame; two panels for the two large dynamos, one for the small one, one testing panel, four for the feeder circuits and one for the works service. The equipment of the switchboard is of the usual character and does not call for detailed description. B. P. S.

223. Electric Tramway at Malakoff les Halles (Seine). C. Dantin. (*Génie Civil*, 39, pp. 383-385, Oct. 12, 1901.)—The total length of the line is 7 kilometres, 6 kilometres being within Paris itself and the remainder without the walls. The cars are fitted with accumulators, by which the former portion of the route is worked, while over the remainder of the line the motors are run from an aerial cable, the accumulators being charged, while running, from the same source. The current is supplied to the overhead system from the Malakoff Electricity Works [see preceding Abstract.] The cells employed are of the "Union" type, 210 in series on each car. The capacity is 45 ampere hours; duration of charge, 15 to 20 minutes. So far the cells have given satisfaction; they are still in good condition though they have travelled over 80,000 kilometres, and been discharged more than 8,500 times. The motors are two in number on each car, each of 35 h.p., of the Thomson Houston Co.'s manufacture; the general equipment of the cars is on the ordinary lines, with the addition of a two-way switch to connect the motors either with the trolley or the cells. The cars are heated as well as warmed electrically, and are provided with compressed air brakes in addition to the ordinary hand-brake. B. P. S.

224. Power Transmission at Crottorf, Saxony. R. Apt. (*Elektrotechn. Zeitschr.* 22, pp. 984-988, Nov. 28, 1901.)—This station has been built by the Helios Company for the purpose of supplying current in an agricultural district. Some part of the power, to the extent of about 500 h.p., is derived from a waterfall 2.7 m. high. Three turbines, each giving 185 h.p., and running at 54 r.p.m., are connected to a common shaft by toothed wheels, to which also a three-phase generator is directly coupled. The generator can also be driven by steam, if necessary, the connection being made by a form of friction coupling. A second steam set of similar capacity is also provided. Each three-phase generator has an output of 500 kw. at 7,000 volts, running at 125 r.p.m. Steam is furnished by five Cornish boilers, built by Paucksch, each being 10.14 m. long and 2.2 m. in diameter. The power is distributed over a radius of 15 km. in twenty-seven villages. Usually alternate current is supplied, but in some of the larger villages the lighting is carried out on the direct current system. This is worked as follows. A battery of accumulators is installed, and is charged during the daytime by means of a motor-generator. The lighting current is then provided by the cells, which discharge in parallel with the motor-generator. But even in these places power is supplied for motor purposes by three-phase current, the distribution throughout being effected on the usual overhead system. W. H. S.

225. The Electric Lighting of Rhode Island. (*Elect. Rev. N.Y.* 39, pp. 563-570, Nov. 9, 1901; and also 1584, 1900.)—The principal interest lies in the magnitude of the installation, the lighting district comprising an area of over 800 square miles, and the number of systems supplied from one station.

The systems in use are, single-phase, alternating at 50, 104, 2,200, and 10,000 volts; two-wire direct current at 500 volts; three-wire at 235 volts, with battery substations; three-phase, 2,200 volts; series (open and enclosed) arc lighting, and series incandescent lighting, with both alternating and direct current, and the usual parallel systems of lighting. F. B.

226. Moulineaux Electric Railway Station. F. Drouin. (*Génie Civil*, 39, pp. 313-318, Sept. 14, 1901.)—The Compagnie des Chemins de fer de l'Ouest has electrically equipped the lines from the Invalides to the Champ-de-Mars,

and to Meudon, and the paper describes the central station at Moulineaux, which supplies these lines. The system adopted is transmission at 5,000 volts, and 25 $\sim$ by three-phase current to substations, where transformers supply continuous current at 500 volts to the line.

The boiler-house contains 27 semi-tubular Meunier boilers, three boilers supplying one engine. The pressure is 12 kg., the heating surface of each boiler 285 sq. m., and the grate surface 3'885 sq. m. The boilers are fired by hand, the coal being tipped into the boiler-house from trucks.

The engine-room contains nine horizontal engines. Six, by Dujardin et Cie, are triple-expansion, four cylinder engines, of 1,850 i.h.p. normal and 1,700 i.h.p. maximum; the cylinder diameters are 0'650, 1'10, and 1'10 metres for high-, intermediate-, and low-pressure respectively, and the stroke is 1'35 metres. The cut-off in the intermediate cylinder is fixed at 85 per cent., and in the low at 50 per cent.; it is governed only in the high-pressure cylinder. The flywheel weighs 20 tons. The other three engines, by Garnier and Faure-Beaulieu, are Corliss cross-compound, of the same power. The cylinder-diameters are 0'71 and 1'32 m., and the stroke 1'80 m. The cut-off is governed in both cylinders. The condenser-pumps are worked off a prolongation of the piston rods. Water is taken from the Seine by six centrifugal pumps, driven electrically by 50-h.p. motors.

Each engine drives directly a Westinghouse generator of 800 kw. normal and 1,100 kw. capacity, at 80 r.p.m. The efficiency is 94 per cent. at a power factor of 0.9. The generators are excited at 110 volts, and take from 175-195 amperes. The exciting current is supplied by four sets, each consisting of a compound engine driving a Westinghouse compound-wound dynamo giving 125 kw. at 290 r.p.m. Scale drawings are given of the boilers and alternators, and several views of the station.

G. H. B.

227. *Birkenhead Electric Tramways.* (Tram. Railway World, 10, pp. 457-462, Sept. 1901.)—System: Continuous-current trolley at 550 volts. The total length of line is 12 miles, of which 7 are double-track; the smallest curve radius is 40 feet, and the steepest gradient 1 in 18 $\frac{1}{2}$. The boiler-room contains three Lancashire boilers by Tetlow Bros., working at 160 lbs. pressure; each has 966 square feet of heating surface and 88 square feet of grate surface. The feed-water is heated by a Green's economiser of 320 tubes, and is fired by McDougall's automatic stokers. The engine-room contains three Willans' engines, each of 860 i.h.p. capacity at 850 r.p.m.; the cylinder diameters are 14 and 23 inches, and the stroke 6 $\frac{1}{2}$ inch. Klein counter-current jet condensers are used, water being taken from a cooling tower and pond. Each engine drives directly a compound-wound six-pole Siemens generator, giving 409 amperes at 550 volts. The generator efficiency is 93.5 per cent., and the combined efficiency of the set 86 per cent. Feeders are five in number, by the Callender Cable Company and the British Insulated Wire Company, and are laid on the solid system. Two return feeders are brought to the station from the rails. The station is equipped with a battery of 241 E.P.S. accumulators (KW type), giving a discharge of 390 amperes for one hour. The track is equipped on the overhead trolley system. Centre and side poles spaced about 40 yards apart carry, by means of bracket arms, two trolley wires of hard drawn copper, 0.4 inch in diameter, insulated by Aetna insulators. The rails are of girder type, weighing 100 lbs. per yard, laid to standard gauge, and tied together by bars every 10 feet. The fishplates are 24 inches long with 6 bolts, and the joints are bonded with double Chicago Crown bonds, No. 0000. The foundation of the track is a bed of 7 to 1 concrete, 6 inches

deep, and the roads are paved with granite and red gum wood. There are 15 single deck bogie motor cars fitted with four motors, and 44 single truck cars, of which 31 are double decked, fitted with Peckham trucks and two G.E. 52 motors. British Thomson-Houston B8 controllers are used on the single truck cars with hand and electric brakes, and Spencer's slipper brake; the electric equipment of the bogie-cars is by Witting Bros. The bogie-cars have a seating capacity of 55 passengers, the single-truck single-deck cars, 34; and the double deck, 58. The average speed, including stops, is eight miles an hour, and the maximum ten. The charge per mile is about 4d., and the maximum 2d. The drawings include a map, rail section, views of station, cars and overhead construction. G. H. B.

228. *Alsaettlan-Berneck Electric Railway.* E. Bignami. (Elect. Rev. N.Y., 89. pp. 309-312, Sept. 14, 1901.)—A general description of a small country railway. It is operated from two stations, one of which is driven by water-power, and the other by steam. The plant consists partly of single-phase alternators, and partly of ordinary tramway generators. The railway is about 7 miles long. W. H. S.

229. *London United Tramways.* (Electrician, 47. pp. 977-981, Oct. 18, and 48. pp. 4-8, Oct. 25, 1901.)—The generating station at Chiswick occupies a ground space of 154 feet by 106 feet, and consists of an engine-room and boiler-house. The internal walls in each case are faced with glazed bricks, and the engine-room floor is laid with mosaic tiles. The equipment consists of ten Babcock and Wilcox boilers, mechanical stokers of the coking type, a coal conveyor capable of handling 40 tons of coal per hour, and a Green's economiser of 860 tubes. The smoke stack, 260 feet high, is chiefly of interest on account of its foundations. Borings were made at several points on the site, and water was met with at depths varying from 8 feet to 10 feet. The soil was found to consist of sand and ballast, with blue clay underlying at about 28 feet below the surface. The site selected for the stack was near the walls of a stone building. It was feared that, were a solid mass of concrete put down here, it might endanger the stability of the walls. The method adopted was as follows: A hollow rectangular structure of pitch-pine was prepared at ground level, tied together in a very strong manner with bolts and stays, and provided with a cast-iron cutting edge. This shoe was filled up with cement concrete, and when this was well set the ground inside was removed, so that with the aid of the pumping operations the whole might gradually subside. A further layer of concrete was then filled in, and these operations were repeated until the blue clay was reached, when the whole of the lower portion was filled up solidly with concrete so as to equally distribute the weight of the superstructure. The engine-room contains two vertical cross-compound Allis engines at 90 r.p.m. Each of these is directly connected with two 250-kw. compound wound direct current generators, one placed on each side of a 36-ton flywheel. Speed variation does not exceed 2½ per cent. from no load to full load. These sets supply the power needed in the vicinity of the power-house. For transmission to substations there will ultimately be three sets giving three-phase currents at 5,000 volts and 25 $\sim$. The generators are of the revolving field type, and are excited from the 500-volt direct current bus-bars. The switchboard consists of twenty-seven marble panels each 7 ft. 6 in. in length and 2 feet wide. The switches and bus-bars for the H.T. work are supported by joists in a closed chamber beneath the switchboard floor, the switches being of the oil break type and operated by

levers on the switchboard. The engine-room also contains two 75-kw. sets for local lighting, and power needs in the repair shops. There are also two 15-kw. negative boosters. A 250-kw. rotary converter, similar to those in the substations, is also installed here. It is used either for transforming alternate to direct current, so as to assist in supplying current to the trolley lines, or it may work the other way and send 5,000 volts to the substations. It is excited by a series generator driven by an induction motor connected to the three-phase side of the rotary. This provides a compensating field and prevents variations in the speed of the rotary from variations in the load. The plant includes two surface condensers and cooling towers provided with air propellers. Practically the whole of the overhead equipment is carried out on the span-wire system. Forty-two feeders radiate from the generating station. They consist of lead-covered paper insulated cables drawn into wrought-iron cement-lined ducts. The whole of the feeding arrangements are duplicated. There are two substations, each about five miles from the power-house, and containing two 250-kw. rotary converters and seven transformers. They are capable of 100 per cent. overload without surging or falling out of synchronism. Each rotary has directly coupled to its shaft a 15-kw. booster. A small induction motor is used for starting the converter. The transformers are of 100-kw. capacity. The secondary voltage may be either 810, 880, or 850 volts, according to which terminals are used. They are delta connected.

W. W. H. G.

230. *Leeds Electric Tramways.* (Tram. Rly. World, 10, pp. 529-538, Oct., 1901.)—The writer states that by the end of 1901, 61 miles of track and 245 cars would be working electrically. The power-house is on the left bank of the Aire, and within 700 yds. of the centre of the tram system. The site affords ample water supply and cheap coal transport. The original boiler-house held nine boilers of the Lancashire type. In the new house six more are being installed of the same size, viz., 80 ft. by 8 ft., and they are fitted with Bennis automatic stokers. An additional Green's economiser of 544 tubes is included. This and the mechanical stokers are driven by a 10 h.p. electric motor. An electrically driven coal elevator and conveyor takes the coal from the boats and delivers it to the hoppers. The rope driven sets have been removed, and the following schedule gives details of the new equipment:—

No.	Engine Makers.	H.P.	R.P.M.	Cylinders.	Pressure.	Amps.	KW.	Dynamo Makers.	Poles.
3.	Hick, Har- greaves & Co.	1,450	90	(H.P. 38 L.P. 54)	150 lbs.	1,600	800	Electric Con- struction Co.	14
2.	John Fowler & Co.	1,300	112	(H.P. 30 L.P. 55)	"	1,500	750	Greenwood & Batley	12

The switchboard has twenty-five panels, fitted with Weston instruments. There are three accumulator substations. The cells are of the chloride type with the capacity of 110, 160, and 400 amp.-hours respectively. The feeder cables are laid in Doulton's casing and iron pipes. The overhead equipment is of the usual kind. A telephone, in connection with the central station, is placed on each section pole, and a key for the telephone is kept on each car in a box with a glass front, the key being obtainable by any one on breaking the glass. The box also contains an "earthing" switch and rubber gloves.

The earth switch is intended for use in the event of telephone or telegraph wires falling on the trolley wire, or in case of the trolley wire breaking. The cars, as a rule, have only the ordinary hand and electric emergency brakes, but six are fitted with Thomson-Houston brake controllers, one with the Westinghouse magnetic slipper brake, one with Milnes', and one with Spencer's slipper brake.

The following statement shows the growth of earnings :—

Year ending Sept. 30.	Car Receipts.
1895.....	£52,704
1896.....	59,959
1897.....	65,957
1898.....	95,527
1899.....	120,477
1900.....	151,702
1901.....	205,428

The passengers carried during the last yearly period were 44,820,890, equal to carrying the whole population of Leeds 100 times during the year.

As an incentive to careful driving, a bonus of 20s. is paid to each driver who, in the opinion of the Claims Committee, has been free from accident during the preceding six months.

W. W. H. G.

231. Sutton and Howth Electric Tramway. (Elect. Rev. 49. pp. 623-624, Oct. 18, 1901.)—The Great Northern Railway Company of Ireland has equipped this tramway to connect the railway stations of Sutton and Howth. The system is overhead trolley, with continuous current at 500 volts. The boiler-room contains three boilers by Taylor & Sons, working at 160 lbs. per square inch. The feed-water is heated by a heater with vertical tubes connected to the exhaust. The engine-room contains three vertical compound non-condensing engines by Ernest Scott and Mountain. These drive directly at 350 r.p.m. three compound-wound dynamos, each of 125 kw.; the compounding can be regulated by a switch. A boosting set of two negative boosters is driven by a motor; the boosters give 160 amperes at 100 volts. A substation contains a battery of 250 Tudor cells, with a capacity of 200 ampere-hours, and a reversible booster, used for charging the cells, and for running in series with them. The battery switch, the motor-starting switch, and the booster switch are each operated by solenoids connected by underground leads to switches in the power-house.

The overhead construction consists of poles with short arms, carrying a single trolley wire 0.825 inch in diameter. Telephone and pilot wires are also carried on the poles. The positive feeders consist of lead-covered armoured cable of 0.15 square-inch section, 7 miles in length; a return feeder of the same size, 2 miles long, is connected with the boosters.

The track is laid with bull-head rails weighing 72 lbs. per yard, carried on chairs resting on sleepers 2 ft. 8 in. apart. The gauge is 5 ft. 3 in. The rolling stock consists of eight double-decked cars, each capable of seating sixty-seven passengers. The trucks are double-bogie Brill, each with one Westinghouse motor. The controller used is B18 by the British Thomson-Houston Co. Three brakes are fitted—an electric brake, a Westinghouse air brake, and a hand-brake. The gradients are continuous and severe, reaching 1 in 16.7.

G. H. B.

232. *Brooklyn Rapid Transit Company*. C. E. Roehl. (Street Ry. Journ. 18, pp. 822-832, Oct., 1901.)—This article contains a summary of the plant at present existing in each of the five stations belonging to the Company. The present plant appears to have a capacity of about 24,000 kw.; but arrangements are being made by which one of the existing stations will be closed, and about 36,000 h.p. of new machinery will be added in a new station. Some of the existing plant is of an old type, being belt-driven; full particulars are, however, given in all cases. The main interest lies in the outline which is given of the new station to be built in the Third Avenue, which will eventually supply about 32,000 h.p. In the first instance 24 boilers, of the water-tube type, by Aultman and Taylor, will be installed, each boiler having 6,500 square feet of heating surface, and a capacity of 650 h.p. There will be two steel chimneys, lined with firebrick, 217 feet in height. The engine-room will contain six 4,000-h.p. engines of the vertical marine type. Four of these engines will be connected to three-phase generators, working at 6,600 volts, and 25 cycles; the other two will drive ordinary railway generators. The engines and generators will have three bearings, one of which is an outboard bearing on the far side of the generator. The cylinders are of 42 inches and 86 inches in diameter, and the stroke is 60 inches; they work at a speed of 75 r.p.m. The diameter of the two engine bearings is 27 inches, and each is 42 inches long; the outboard bearing is 30 inches in diameter, and 56 inches long. In the generator, the diameter of the shaft, which is of hollow forged steel, is 35 inches. The 28-foot flywheel weighs 107 tons, and the crane will lift 50 tons. The alternate current will be transformed by rotary converters in substations; there will be eleven of 1,000 h.p. each, and five of 500 h.p. (W. H. S.)

233. *Portsmouth Electric Trams*. (Tram. Ry. World, 10, pp. 539-548, Oct., 1901.)—The site of the power-house is practically central. The engine-room is 119 feet long, 52 feet wide, and 52 feet high. It has a fireproof floor constructed on steel girders. There is a basement beneath for access to pipes, &c. The boiler-house is 65 feet long, 47 feet wide, and 55 feet high. The three Babcock boilers are fitted with superheaters. Three surface condensers are provided of the Admiralty type. Steel cooling towers have been erected, and furnished with direct-connected motor fans. The plant consists of two 400-kw. sets and one 200-kw. set. The engines are by Yates and Thom, driving generators of the English Electric Manufacturing Company.

The track and overhead equipment is generally of the standard character. The thoroughfares are somewhat narrow, in one case being only 18 feet in width. (W. W. H. G.)

234. *Switch-gear of the Lausanne Central Station*. K. P. Täuber. (Elektrotechn. Zeitschr. 22, pp. 825-829, Oct. 3, 1901.)—The Lausanne Central Station contains five 400-h.p. units, giving three-phase current at 3,100 volts. The article describes the switchboards, switch, and instrument pillars, and the general scheme of connections. It is fully illustrated. (G. H. B.)

235. *Hydraulic Power Station at Colgate, California*. (Elect. World and Engineer, 38, pp. 588-596, Oct. 12, 1901.)—Water is taken from the North Yuba River, and carried in a flume, $7\frac{1}{4}$ miles long, to a point 700 feet above the river; the drop in the flume is 18 feet to the mile. From the penstock five pipes, of 30 inches diameter, carry the water to the power-house; they

are of steel at the top and cast iron at the bottom. The plant consists of three sets of 8,000 h.p. each, and four of 1,500 h.p., consisting of Risdon Iron Works impulse wheels connected to the three-phase 60 $\sim$ Stanley generators. The wheels are governed by Lombard governors and deflecting nozzles. The pressure at present in use is 40,000 volts, and the plant is so arranged that this can be increased to 60,000 volts when required.

The transmission line to Oakland, a distance of 142 miles, consists of two distinct pole-lines, each carrying three wires arranged at the angles of an equilateral triangle, with sides of 36 inches. Transpositions of one-third of a turn are made every mile. One of the pole-lines carries three No. 00 hard-drawn copper wires, and the other three No. 0000 7-strand aluminium cables.

G. H. B.

ELECTRIC TRACTION AND AUTOMOBILISM.*

236. Recent Tramway Practice. J. More, Jr. (Tram. Rly. World, 10, pp. 497-509, Sept., 1901. Paper read before the Engineering Congress at Glasgow, Sept., 1901.)—This paper deals mainly with electric traction practice during the last five years, considering permanent-way construction over a longer period, this being of less recent development.

PERMANENT WAY. Rails.—The steel employed has changed from a 0.35 percentage of carbon to one of from 0.55 to 0.65, giving a much harder and more durable rail, yet sufficiently tough, with an ultimate tensile stress of 45 tons per square inch, with an elongation of 15 per cent. and a contraction of over 40 per cent. in a 2-inch test piece. Rails now weigh from 80 to 100 lbs. per yard, and are invariably of girder section. The standard length of 45 feet is sometimes extended to 60 feet, where transportation difficulties do not intervene. The sections have much improved through the relaxation, to some extent, of Board of Trade objections to wide grooves and broad treads, this being largely due to corporations adopting sections which would not have been allowed to a private company. Until recently rails were rolled with a much too obtuse angle at the shoulders or fish-bed. The author's suggestion of reducing this almost to a right angle was first adopted for the Cape Town Tramways, and this improvement has now become general. The author is averse to the use of sole-plates, and considers that the main point of good vertical stiffness is best obtained by the use of heavy fish-plates with good fish-beds, and a tight solid concrete bed under the plain rail flange. He advocates the use of fish-plates with six 1-inch bolts to each pair of plates.

Points and Crossings.—Objection is taken to the practice of some American firms of making cast-steel points and crossings with special hard filling pieces of manganese steel, where the wheels of the cars drop. This involves a large surface of exposed metal with consequent danger to horses. The renewable filling pieces are also liable to work loose. As the authorities now permit a much larger metallic surface on the roads than formerly, chilled iron points can be made with sufficient body of metal to withstand the lateral shocks from heavy cars, and they are greatly superior in durability to cast steel.

Foundation.—The method preferred by the author of laying a concrete foundation is to lay the concrete as truly level as possible, but about 1 inch lower than the finished level of the rail flange, and, when set, to place and level the rails, and pack from both sides. Plastering the haunch of the rails is

* Non-electrical Automobiles are described in the section dealing with steam and gas engines.

objectionable, as it neutralises the advantages derived from the elasticity of pitch grouting, which should always be used, besides facilitating the entry of water. *Paving.*—The setts are now laid quite closely, and this is found to be less dangerous to horses, instead of more so, as was anticipated. In macadam roads the paving at the margins should be finished with a straight joint to avoid trouble in rolling.

Traction Systems.—Reference is made to cable traction, which is of value on some routes with heavy gradients, but present-day traction is electric. The author considers that if a light, durable cell should be discovered which could be charged in about one-third of the time now taken, the accumulator system would supersede all others, but at present it is not financially practicable. Surface-contact systems have not yet passed the experimental stage, and the studs are objectionable in a roadway. The conduit system has yet to prove its financial advantages in this country. The author agrees with Kennedy that the large conduits used in America are unnecessary here, and considers that in his recent designs for the London County Council Kennedy has reduced the conduit to the minimum of cost and capacity.

Central Station Plant.—The author prefers the Galloway boiler, its thorough circulation giving a high efficiency and good steam-raising power. Water-tube boilers are of advantage in combined lighting and traction stations, as their greater steam-raising power can better cope with the concurrence of the two load maxima. They are also useful where space is restricted. Economisers are a necessity. Conveyors can be made profitable in some very large stations. Mechanical stokers are useful in avoiding black smoke, and generally advisable where first cost is not a primary consideration. The author disapproves of electric driving for feed-pumps, electric motors being out of place in the boiler-house. He advocates the supplementing of the feed-pumps by injectors and using them to feed through the economisers. The considerations governing the selection of the type of engine are considered, and illustrated by the results of trials. A typical generator specification is then given, followed by tables of the comparative results obtained on some important tramway systems.

Transmission System.—Great stress is laid on care in bonding, and the not uncommon practice of giving it out as piecework to ordinary mechanics is strongly deprecated. The author prefers the fastening of the Neptune bond to any other. Examples are then given of dimensions and physical tests of trolley-wire poles and of trolley wire. The importance of careful soldering of the trolley wire to the ears is strongly insisted on, and the amount of tension put on in erecting the wires should not be left to the judgment of the foreman of the gang, especially when erected in the summer, in which case too great tension will probably lead to many breakages when the temperature falls. The strength and tension of guard wires should receive due attention, or they may become an actual source of danger. There should be two lightning arresters on each half-mile of track, and, unless the ground plate can be "earthed" in running water, it should be embedded in fine coke. In discussing the cables the author gives the following as a useful test as to the fatigue which the insulation will stand in threading:—A piece of cable is wound round a drum three times in one direction and three times in the opposite direction. It is then immersed in water, and must stand a pressure of 2,000 volts alternating for 15 min. without breaking down. For cables of 0.2 square-inch area the diameter of the drum should be 1 ft. 6 in., and 2 ft. 6 in. for large cables. Illustrations are given of a manhole for drawing

in cables, and also of feeder switch-pillars, which should each be provided with lightning arresters.

Rolling Stock.—The four-wheeled car is most suitable for all-round work, owing to its economy in power as compared with the eight-wheeled bogie car, and it has more adhesion on severe gradients, owing to there being less distribution of the weight. The latter, however, runs more smoothly, is easier on the rails, and is preferable for high speeds and small curves. Motors are then discussed, and a sample specification of a 25-h.p. motor is given, with illustrations and curves. With regard to controllers, the author prefers the solenoid blow-out to the magnetic type, on account of the smaller damage by flashing. He considers that there is at present a tendency to the use of too many emergency brakes, adding to the weight of the car, and the confusion of the driver when an emergency occurs. The brakes advocated by the author are:—(1) An air-brake, which is an independent unit, and the most speedy, and therefore specially suited for emergencies. It should be applied to the wheels and used as the ordinary brake, more especially on descending gradients. (2) A hand-brake fitted as a slipper brake to act on the rails, and actuated by a screw spindle with a heavy hand-wheel, so as to give delicate application and act as little counter as possible to the wheel-brake. (3) An electrical emergency brake to act on the wheels or axle.

The paper concludes with some remarks on operation and general management, in the course of which the author points out the importance of the suitable location and distribution of car sheds in saving loss of time both of men and cars.

G. W. DE T.

237. *Tramway Power Stations for Polyphase Plant.* J. E. Woodbridge. (Elect. World and Engineer, 88. pp. 592-596, Oct. 5; 592-594, Oct. 12; and pp. 688-641, Oct. 19, 1901.)—The author considers the case of a line with half-hourly service and having each car equipped with motors aggregating 50 h.p. For such a service, supplied from substations 10 miles apart, he would employ a rotary converter of 800 kw. in each substation, with a similar machine in reserve. The periodicity of the three-phase circuit is assumed to be 25, and the voltage of the main feeders from 10,000 to 15,000 volts, which latter is the highest which can be safely generated in the usual sizes of alternators without having recourse to step-up transformers. The step-down transformers in the substations he assumes to be of the air-blast type, the blowers being driven by small induction motors, and giving a pressure of about $\frac{1}{4}$ oz. per square inch. The whole of the substation equipment is closely considered, and many useful details are given of the actual buildings themselves—floor construction, wiring, attendants' quarters, &c. Regarding danger from fire, the author says that the location of substations is usually such as to expose them to much greater fire risks than generating stations. The added cost of fireproof construction per kw. capacity installed is, moreover, no greater in a substation than in the generating station, and the loss of revenue due to a line being shut down in case of fire warrants the added cost of incombustible construction. Regarding the conductors, the author is in favour of running them in the blast chamber and specially built flues, and having them bare and supported on "Redlands" porcelain insulators. Brick, tile, and concrete slab barriers are used between the leads. A long creepage distance is necessary between each wire and the wall of the building where exposed to the weather. This is provided by anchoring the outside line to a porcelain strain insulator of a type with eave-shaped corrugations both above and below the fastening of the wire. From this strain insulator the wire

passes upward into the building through a porcelain bushing with a corrugated top indoors and a petticoated lower portion out of doors. The building has an extension over these insulators not unlike a dove-cote in appearance. Regarding the generating station the author is of opinion that the location of the switchboard at the end of the engine-room is not to be recommended, owing to difficulties of extension, as well as length of leads and distance from machines at the opposite end of the room. The distribution of electrical apparatus along the side of the engine-room opposite to the boiler-room wall almost invariably gives the best results. Since the travelling crane need not span the switchboard, oil switches, &c., these can be placed in a sort of lean-to, outside the crane and roof supporting columns, thereby giving a considerable saving in the cost of the crane and of the main roof trusses.

The articles are exceedingly well illustrated by fifteen line drawings.

E. K. S.

238. Polyphase Tramway Power Plant. M. G. Starrett. (Str. & Rly. Journ. 18. pp. 259-265, Oct., 1901.)—This paper deals with the engineering considerations involved in the design, and in the practical results obtained in actual operation, of the Metropolitan Street Railway of New York.

Practice has shown that for electric railway purposes, where a large amount of power is used, but where the amount of power needed near any one point is small, polyphase distribution is the most suitable system. In this instance a comparison between the cost of serving the district from one polyphase or two direct-current stations showed that the cost of feeders alone in the latter system made it prohibitory, whilst the use of several direct-current generating stations, which would have brought down the cost of feeders, was out of the question, owing to the cost of land. The cost of the generating plant would have been about the same for direct as for alternating current, the cost of the commutators in the one case being counter-balanced by the cost of the switching apparatus in the other. Eight out of the eleven generating sets are at present in operation.

The space per kw. at Ninety-Sixth Street power-house is 0.68 square feet in the engine-room, and 0.56 square feet in the boiler-room, total 1.24. These figures are said to be from one-half to one-fifth those obtaining in other stations [American stations with horizontal engines probably referred to]. Space is economised by using the same sized unit throughout.

Analyses of coal, oil, and flue gases are regularly made, the flue gas being taken from the back connection of the boilers. The water evaporated per lb. of coal is 8.4 lbs.; the coal consumption per kw.-hour 2.65 lbs., and the water consumption per kw.-hour at switchboard, 22.41 lbs. (this includes all coal-hoisting, stoking, and auxiliary machinery); 14.9 lbs. of water are evaporated per i.h.p.-hour (including auxiliaries). There are 72 boilers, and the useful boiler-hours are 58 per cent. of the total—that is, out of 1,188 boiler-hours, 679 are useful, and 489 reserve. [See also Abstracts Nos. 1872, 1873, and 2112 (1900).] F. B.

239. Polyphase Distribution for New York Tramways. W. A. Pearson. (Street Rly. Journ. 18. pp. 266-272, Oct., 1901.)—Notable as being the largest street railway system in operation, and distributing an unusually large amount of energy per square mile, a comparison of the costs of distributing from two direct-current stations, or from a single polyphase generating station with six substations, showed that the former would cost about £840,000 more than the alternating system. This includes the cost of real estate and of the

feeder system; the feeders alone would involve an additional cost of about \$172,000. The feeder capacity is 26,000 kw. at 6,400 volts. The district served is 9 miles long by 2 miles wide. A storage battery is installed at each substation, having a capacity of about 25 per cent. that of the rotary converters. The battery is considered a very good investment. The efficiency of the distributing system, including the high-tension feeders, static transformers, and rotaries is 90 per cent. as shown by the difference in the records of the wattmeters in the power station, and those in the direct-current bus-bars at the substations. The high-tension feeder loss is from 3 per cent. to 7 per cent. Owing to the large number of instruments in use, and the need for accuracy, two men are employed to give their whole time to checking them. The method of checking is described. In all there are 750 switch-board instruments, including 84 recording wattmeters. In designing the system 16,500 watts (33 amps. at 500 volts) were allowed per car. The energy per car-mile is about 2,100 watt-hours at the substation board, including the lighting of car-houses, &c. Tests on individual cars show a consumption of 1,500 watt-hours per car-mile. Maps of the district are given showing the feeders, also load curves, e.m.f., and current diagrams. Sample sheets from the feeder and conduit record books are also given. [See also preceding Abstract.] F. B.

240. Storage Batteries in Traction Power Stations. W. E. Harrington. (Street Rly. Journ. 18. pp. 472-475, Nov., 1901. Paper read before the Amer. Street Railway Association.)—In this paper figures and curves are given showing the effect of a battery at the generating station in diminishing fluctuations of current in street railway circuits. An incidental advantage of the battery is that it acts as a very efficient lightning arrester. Batteries at substations, besides smoothing out fluctuations, result in a considerable economy of copper in the feeders, and the constancy of line voltage attained diminishes motor depreciation; the engines also work more steadily and therefore more economically. The site of the sub-battery station is of great importance. The formula—

$$\text{Cost of copper} = 804 \left(\frac{c_1 d_1^2}{V_1} + \frac{c_2 d_2^2}{V_2} + \frac{c_3 d_3^2}{V_3} \right) \text{ dollars}$$

is given, where c , d , and V are the mean current, volts lost, and length in miles of the three feeders, viz., power station to substation, substation to near end of line, and substation to extreme end of line. $d_1 + d_2$ and $d_2 + d_3$ are constants; the cost should be worked out for different values of d_2 and with V_2 and V_3 bearing different ratios to V_1 , and the length of d_2 which gives the lowest cost of copper gives the best position for the sub-battery station.

B. P. S.

241. Storage Batteries and 60-Cycle Railway Rotaries. E. L. Reynolds. (Street Rly. Journ. 18. pp. 402-404, Nov., 1901.)—This paper contains a description of the method in which storage batteries are employed at Hamilton, Ontario, to steady the load on rotary converters supplying current for railway work, so that it becomes possible to run incandescent and arc-lighting circuits and alternating motors from the same high-tension transmission circuit which supplies the rotaries. Transmission is at 22,000 volts, three-phase, the current being generated at 2,400 volts, two-phase, and stepped up; the length of the transmission line is 34 miles. At the substation are static transformers, three rotary converters (each 800 kw., 66

periods, with 550 volt secondaries), and a storage battery of chloride accumulators with a capacity of 400 amperes at 550 volts, which is run in parallel with the rotaries on the railway circuits. Voltage curves are given showing the variation of pressure on one of the 110-volt lighting circuits (a) when the battery is in use, (b) when it is off, the local conditions being the same in each case. The first curve shows a maximum variation of 5 or 6 volts in a run of 5 hours, the second of about 22 volts in the same time. Other advantages of the battery, besides that of regulating fluctuations, are pointed out, such as the obviating of a temporary shut-down in case of slight accidents to machinery, and the possibility of operating the railway service from the batteries alone in the hours of light load, thus ensuring an all-night service without the need of running the rotaries continuously. B. P. S.

242. Modern Electric Railway Switchboards. G. U. G. Holman. (Street Rly. Journ. 18, pp. 407-416, Nov., 1901.)—Slate and marble for switchboards should be carefully selected and tested before use. Slate should not be used for working pressures over 1,000 volts. Enamelled slate is better than marble for railway working. Marble for pressures over 8,000 volts should be polished on both sides. With the aid of insulating bushes, marble may be used for pressures up to 15,000 volts. The current density in the jaws of knife switches should not exceed 50 to 100 amperes per square inch. Bolted contacts may take from 100 to 200 amperes, and laminated brush contacts up to 500 amperes per square inch. Tables of the sizes of main and equaliser cables for various sizes of generators are given, as well as of the necessary distance between metal parts at a p.d. of 500-600 volts. Six inches is the maximum distance required. Full details are given of the construction and equipment of standard railway switchboards. For large outputs it is better to put all the positive main and equaliser switches close to the machines, and to have only negative switches on the board. With the negative bus-bar earthed it is better to equalise on the positive than on the negative pole, to guard against a possible internal earth in the machine; the resulting damage is likely to be much less in the former case. This does not apply to rotary converters.

The connections of a high-pressure three-phase switchboard are discussed, with the methods of working in use. Relays in the low-pressure ammeter circuits are used to operate the circuit-breakers. The rotary converter connections are also explained. When circuit-breakers for high pressures are placed at a distance from the board, automatic visual signals are necessary to show their condition. In designing these circuit-breakers it is necessary to know, not only what their normal duty will be, but also the capacity of the whole station, which might be thrown upon one of them in the event of a short-circuit occurring. Methods of synchronising are discussed, and the two-voltmeter system is recommended. Great importance is attached to making ample and suitable provision of space in the station for the cables and switchboards. The article is fully illustrated. A. H. A.

243. Third-rail Interurban Electric Railways. M. Hoopes. (Street Rly. Journ. 18, pp. 887-889, Oct., 1901. Paper read before the New York State Street Rly. Assoc., Sept., 1901.)—The author refers to the New York, New Haven, and Hartford Railroad [see Abstracts Nos. 218 and 716 (1898), and Abstract No. 866 (1899)], and the Albany and Hudson Railway [see Abstract No. 1482 (1901)], and gives data showing that the cost per mile of track of third-rail construction is about £682, while that of overhead trolley-wire construction is about £884, the former showing a saving of 23 per cent. The

track must be carefully fenced in, unless street railway tracks are used at the termini, in which case the cars must be operated on the trolley system at these points. To change from the third rail to the trolley wire requires about 15 seconds. The author objects to guards over the third rail, and states that the danger inherent to its use is small compared with the other dangers unavoidable in railway working. Objections are raised to placing the third rail between the track rails; it should be outside one of the latter, and elevated several inches. The insulators should be mechanically strong, and should not be rigidly attached to the third rail. The latter should be made of a special low-carbon steel, which may have a specific resistance as low as 12.9 microhms per c.c. By giving the third rail a sufficiently large cross-section—generally 80 lbs. per yard—copper feeders are rendered unnecessary, the converting stations being 10 to 12 miles apart. The collecting shoes should be spaced so that they do not pass over joints in the third rail simultaneously. At level crossings the rail is interrupted, the circuit being completed by underground cables. The greatest weather trouble with the third rail occurs in sleet storms, when a film of ice is formed which it is very difficult to remove quickly. Snow gives no trouble. A. H. A.

244. Multiple Unit System for Electric Railways. M. Kubierschky. (Elektrotechn. Zeitschr. 22. pp. 558-563, 1901.)—The system here described has been designed by the author and E. Volkers for the Union Electricity Co., of Berlin, and is described in the German Patents Nos. 114048 and 119972. Each carriage has its own controller, the various controllers being operated by means of an auxiliary motor, which is worked by the driver. It differs from the Sprague system [see Abstract No. 395 (1898)], and that of Siemens and Halske (German Patent No. 104940), inasmuch as the motor is mechanically connected to the controllers by the action of solenoids, which are connected in series with the auxiliary motor; and the various controllers are operated by the motor in the one direction only, movement in the reverse direction being produced by means of a spring or dead weight. The article contains an elaborate description of the various details, together with several drawings and illustrations. The method has been applied on a local railway in Baden between Karlsruhe and Ettlingen. W. H. S.

245. Report of Committee on Standards of the American Street Railway Association. (Street Rly. Journ. 18. p. 483, Nov., 1901. Paper read before the American Street Railway Association.)—The report is accompanied by sectional drawings illustrating the recommendations of the Committee with respect to rail sections, car wheels, axles, journals and brasses, car bodies, and the electrical and overhead equipment.

A T-rail is recommended as the most desirable under any conditions, and it is stated that with a rail-head and car-wheels of the form and dimensions set forth a tramway can be operated at a minimum cost for track and maintenance, without interfering with the pavement in cities, and with safety on suburban roads. G. W. DE T.

246. Economy of Electric Traction on Railways. C. A. Carus-Wilson. (Elect. Rev. 49. pp. 498-494, Sept. 20, 1901. Abstract of a paper read before the Glasgow Engineering Congress.)—The author compares the actual running expenses of English steam railroads with the calculated costs of electric traction. Taking the Great Northern Railway as a representative line, and allowing for the high price of coal, the running expenses per train

mile are shown to be 11-85d. The estimated running expenses for electric traction are 4-89d., while the actual expenses of the Liverpool Overhead Railway are 5-17d. W. R. C.

247. *Tests of the Scheinig and Hofmann System of Rail-Bonding.* A. Kvetensky. (Zeitschr. Elektrotechn., Wien, 19. pp. 548-545, Nov. 10, 1901.)—This paper gives particulars of some tests made on the electric street railway at Linz-Urfahr with this rail-bond, for a description of which see Zeitschr. Elektrotechn., Wien, 19. p. 118, 1901. The cost of a 16-cm. shoe, retaining the copper-bond and fish-plate, fitted to the rails, is K. 14-04, and that of a shoe 20 cm. long, without fish-plate and without copper-bond, is K. 16-64. C. K. F.

248. *The Conveyance of Goods on Electric Trolley Lines.* A. H. Gibbings. (Tram. Rly. World, 10. pp. 576-578, Oct., 1901. Paper read before the British Association at Glasgow, Sept. 14, 1901.)—The author advocates the free use of trolley lines for the conveyance of traffic, instead of the canals, railways, and horse luries at present employed.

The ideal scheme for the conveyance of goods in such an area as South Lancashire should comply with the following conditions: (1) The goods should be loaded direct from ships, warehouses, or depôts, and deposited without further handling at their ultimate destination; (2) In order to carry out the above condition transit should be on highways, and special sidings run into warehouses, mills, &c.; (3) There should be no special stoppages or delay in transit from the loading point to the destination; (4) The service, when necessary, should be continuous for the whole twenty-four hours per day, excluding perhaps Saturdays, Sundays, and public holidays, but even on these days a service should be available if urgently required; (5) No shunting operations should be necessary, and hence marshalling is avoided. Not more than two trucks (motor and trailer) should be marshalled together; (6) One or two special forms of trucks should be used for all classes of goods; (7) The service should be expeditious, but not necessarily entailing a high rate of speed; (8) The system should possess every facility for the transference of goods (without handling in piece) to or from railway trucks or horse luries; (9) The line for conveyance of goods should not be in any way designed exclusively for that purpose, but it should not interfere with any passenger or ordinary road traffic; (10) No alteration in the existing gradients of the roads should be necessary; (11) The maximum weight to be carried on each truck should be not less than 9 tons; (12) The charges should be reasonably economical, and should compare more favourably with American and Continental railway rates than do the present British railway rates.

Electric trucks have the same advantage as horse luries, in that they can be moved immediately they are loaded and replaced by empty ones. In railway traffic there is an enormous waste of time in marshalling the trucks, to say nothing of the expense of moving the merchandise from luries into the depôts, from depôts to trucks, and again, at the destination, from trucks to depôt and depôt to luries. By a well-thought-out system of electric traffic traction along the main roads and sidings into the various works, most of this waste would be entirely done away with. The author makes a comparison of the time taken to deliver goods by ordinary railway and luries from Liverpool to Bolton, 29 miles, and makes it 24 hours; whereas, with an electric service, it could be done in about 4½ hours. Two miles cartage is taken at 1s. 8d., and railway carriage, with station terminal charges,

at 9s. 7d. per ton-mile for Class 1 merchandise, cotton, &c. Two kinds of trucks are proposed—one on the lines of a Pittsburg express car for conveying miscellaneous goods and for local traffic, and the other to be an application of the principle adopted by the South-Eastern Railway and the Lancashire colliery railways. The South-Eastern Railway employs a detachable van, fitted with steel lifting ropes, which rests upon the top of a flat railway truck. The collieries use coal waggons fitted with three detachable boxes, each box carrying $2\frac{1}{2}$ to 3 tons of coal. When it is required to discharge the coal a box is lifted by lifting rings, and a bottom door opened, or, the usual tip method is adopted. The comparative sizes of the trucks, &c., are as given below:—

Proposed electric trolley truck	22 ft. by $6\frac{1}{2}$ ft.
Ordinary railway truck	16 ft. by 7 ft. 10 in.
Ordinary two-horse lurry	$17\frac{1}{2}$ ft. by $7\frac{1}{2}$ ft.

A train would consist of one motor truck and one trailer, and they would together carry 18 to 20 tons. They would be of good design and not nearly so unsightly as the horse-driven lurry, while great public benefit would accrue from the relief of the streets from lurry traffic. The Surveyor of Tydesley, U.D.C., finds the cost of road maintenance for four years averages £288 2s. per mile per annum, exclusive of scavenging. It has been shown that the greater proportion of the road wear is from horses' shoes, as illustrated in the following table:—

GENERAL RESULTS OF OBSERVATIONS OF CAUSES OF ROAD WEAR AND
DETERIORATION.

Kind of vehicle and load.	Wear due to atmospheric causes.	Wear due to wheels.	Wear due to horses' feet.
	Per cent.	Per cent.	Per cent.
London and Birmingham. Coaches: Weight, 16 cwt. to 18 cwt., empty; loaded, 45 cwt. Speed, 8 to 12 miles per hour	20	20	60
Waggons: Weight, 25 cwt.; loaded, 92 cwt. Speed, 8 miles per hour...	20	85.5	44.5

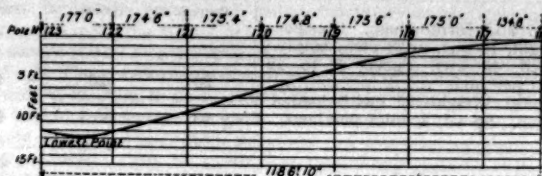
E. K. S.

249. *Tramway Track Construction.* **E. H. Packe.** (Street Rly. Journ. 18. p. 886, Oct. 1901. Paper read before the N.Y. State Street Railway Association, Sept., 1901.)—The author, who is one of the engineers of the Brooklyn Heights Railroad Co., thus describes their standard construction in streets where the pavement is granite block on concrete foundation. The street is excavated to the sub-grade, which is levelled off with sand. On this are laid the ties, 6 in. by 8 in. by 7 ft., with tamped foundations. On these are spiked the 9-inch girder rails, 60 feet long with brace tie-plates every third tie, Weber joints being used for splicing. Portland cement concrete is rammed between and around the ends of the ties, forming a solid bed of 6 inches above the sub-grade between the tracks and rails, and for 2 feet outside. On this is laid an inch of sand, in which the granite blocks are bedded. Another form of construction consists in placing the rails on concrete beams; these beams are 10 inches by 12 inches in section, and are placed beneath each rail. The author's experience shows that this latter

form of construction is much more expensive, and that the wear of the rails is also much greater. Drawings are given showing the wear of rails on both forms of track after five million cars had passed over them. W. H. S.

250. *Tramway Costs.* (Street Rly. Journ. 18. p. 840, Oct., 1901.)—An elaborate table is given with this article showing the receipts and expenses, under a large number of items, of the Metropolitan Street Railway Company of New York for the three years 1899–1901. The Company owns cable, electric and horse trams, the accounts for each being given separately. In the last year, *i.e.*, from June 30, 1900, to June 30, 1901, on the electric lines the passenger receipts were 38.74 cents per car-mile, and the operating expenses 18.56 cents. On the cable trams, these figures were 36.81 cents, and 18.59 cents respectively; and on the horse trams, 22.7 cents, and 19.19 cents. The operating expenses on the electric lines are made up as follows: maintenance of track, 0.88 cents per car-mile; repairs of cars, 1.78 cents; power including all power-house expenses, 1.78 cents; transportation, including wages of motor-men, conductors, inspectors, car-cleaners, &c., 7.02 cents; office expenses, compensations, and general expenses, 2.15 cents. W. H. S.

251. *Tests of Roller Bearings.* W. H. Booth. (Tram. Rly. World, 10. pp. 557–562, Oct., 1901.)—The author points out that by the use of wheels and axles the tractive resistance on rails is decreased some 98 per cent., so that about 2 per cent. only, representing some 11 or 12 lbs. per ton, is the reduction that is possible by the use of a perfect roller bearing. With the rapid acceleration required in tramway practice, the amount of starting current that can be saved by roller bearings forms a very small proportion of the whole. On ascending grades the extra power required will be practically the same whether plain or roller bearings are employed. On descending grades the car may take less current on very gentle slopes, but on steeper gradients braking will be



necessary, and this will be greater with roller bearings than with plain ones, with greater wear of wheel rims and shoes, but less axle wear. Outside these points the economy will simply be equivalent to the power saved on a level road.

In making the tests described in this paper a straight section of line was selected with a slope sufficiently flat to prevent a car from acquiring a dangerous rate of speed, when started from rest at the top of the slope, and allowed to drift freely down-hill under the influence of gravity. The starting effort was that due to a rapid snatch, on and off the first notch, of the starting handle. The post distances and the slope are shown in the accompanying diagram. The times of passing each post were noted, and the distances measured between the posts. One set of tests was made by allowing the cars to drift down the slope under the action of gravity, and with similar conditions of weather, load, &c. The cars tested were exactly similar, except that one had ordinary white metal bearings, the other the bearings to be

tested. The load was about 1,800 lb. Owing to the speed of the record as varying with the amount of winding up of the springs, the record strips did not correspond in length with the actual times, but this introduced no serious error, as the areas of the diagrams were measured by a planimeter, set, in each case, to the length of the diagram, so as to measure the mean height. The results are given in the accompanying tables.

TABLE I.
ROLLER BEARINGS, CAR A.

1	2	3	4	5	6	7	8	
No. of Notch.	Length of Paper.	Apparent Equivalent Time.	Actual Time.	Maximum Amps.	Volts.	Average Amps. of Current.	7 x 4 Amps. x Time.	Remarks.
	Inches.	Seconds.	Seconds.		500		Amp. Seconds.	
1	6 $\frac{3}{4}$	127.5	137	6	Voltage on each day practically identical.	4.700	648.8	
2	7 $\frac{1}{4}$	147	133	5		3.375	448.8	
3	7 $\frac{1}{2}$	145	128	5		3.870	495.8	
4	7 $\frac{1}{2}$	145	127	5		3.437	456.5	
5	6 $\frac{3}{4}$	127.5	110	8		6.060	666.6	
6	5 $\frac{1}{2}$	105	87	19		12.500	1087.5	
7	4 $\frac{1}{2}$	95	82	21.75		12.900	1058.0	
8	5 $\frac{1}{2}$	103	88	21.5		12.000	1056.0	Controller put slowly on.
Drift	6 $\frac{1}{4}$	125	112	—		—	—	
"	5 $\frac{3}{4}$	117	102	—		—	—	
"	6 $\frac{3}{4}$	127 $\frac{1}{2}$	110	—		—	—	

TABLE II.
WHITE METAL PLAIN BEARINGS, CAR B.

1	2	3	4	5	6	7	8	
No. of Notch.	Length of Paper.	Apparent Equivalent Time.	Actual Time.	Maximum Amps.	Volts.	Average Amps. of Current.	7 x 4 Amps. x Time.	Remarks.
	Inches.	Seconds.	Seconds.		500		Amp. Seconds.	
1	8	160	155	7	Voltage on each day practically identical.	5.810	900.2	24.48%
2	6 $\frac{1}{2}$	137	139	7		6.000	834	46.18%
3	6 $\frac{1}{2}$	124	133	7 $\frac{1}{2}$		6.125	814.4	39.18%
4	6 $\frac{1}{2}$	132	130	7 $\frac{1}{2}$		6.125	796.2	45.18%
5	5 $\frac{1}{2}$	112	115	9		7.500	862.4	22.7 %
6	4 $\frac{1}{2}$	85	86	18 $\frac{1}{2}$		15.300	1301	16.41%
7	4 $\frac{1}{2}$	85	84	20		15.200	1277	17.15%
8	4 $\frac{1}{2}$	87	84	21.5		15.125	1270.8	16.9 %
Drift	10	200	194	—		—	—	Controller put slowly on, but more quickly than on car 2.
"	7 $\frac{1}{2}$	152.5	160	—		—	—	Brake probably on slightly.
"	7 $\frac{1}{2}$	150	157	—		—	—	

It will be seen that the roller bearings had very little effect on the time occupied in each uphill run. The power, however, is considerably less in the case of the car provided with them. If for each car the sum be taken of the amounts of current in notches 2, 3, 4, the mean difference is 2.528 amperes, which appears to be the saving due to the roller bearings, and approximates closely to the 2.742 amperes found as the mean difference of the two cars in notches 6, 7, and 8, these latter being controller positions with the two car motors in parallel.

In the series running it works out to 354.7 ampere-seconds saved in a run of 1,187 feet, which means in this case nearly 4 h.p., corresponding to an extra traction resistance of about 15 lbs. per ton. The total weight of each car was about $7\frac{1}{2}$ tons.

The average current taken per car on this line is about 14 amperes, so that a saving of $2\frac{1}{2}$ amperes is about 17 per cent. This apparent economy will, however, be reduced in the ratio of the time of standing and of downhill running with no current, to the total time. The author estimates therefore the maximum economy, on the basis of these tests, as not exceeding 10 per cent., while it may fall as low as 6 or 8 per cent.

G. W. DE T.

252. *Block Signal Apparatus.* (Elect. World and Engineer, 38, pp. 500-502, Sept. 28, 1901.)—This paper describes the mechanism in the post devised by C. W. Coleman, of the Hull Signal Company. The post carries home and distant signals. An electromotor is geared, by a double set of reduction gears, to the axle carrying the crank to which the up-and-down rod of the semaphore is connected. The gears are kept from revolving backward by a ratchet. The crank operating the up-and-down rod of the signal is not permanently fastened to the axle upon which it turns, but is free to turn independently of the gear, except when held by an electromagnetic clutch. When a signal is to be pulled to "clear," the motor and clutch circuits are closed, and when the signal is at "clear," a cam switch connected with the rod opens the motor circuit, and the signal arm is kept in position by the clutch, and a ratchet acting on the motor gearing. To put the signal to "danger," the clutch is released, and the rod, which is heavier than the arm, overbalances the latter and brings it back to its normal position. There are cranks and clutches for two signals. The motor is a $\frac{1}{4}$ h.p. Crocker-Wheeler. The power required for clearing a signal, about 4 amperes at 6 volts for ten seconds, is obtained from caustic potash batteries. Half the amount of energy is required as compared with early types, with the same factor of safety on the counterweight.

E. O. W.

253. *English and American Railway Signalling.* J. Pigg. (Elect. Rev. 49, pp. 508-505, Sept. 27; 539-540, Oct. 4; 582-583, Oct. 11; 663-664, Oct. 25; and pp. 701-705, Nov. 1, 1901.)—The author describes the development of railway signalling in America, and contrasts the methods now in use in that country with those employed in England. One of the most general is known as the Controlled Manual System. One operator releases the lever of the other, but the process is governed by the train. The releasing apparatus is arranged so that it can be operated but once for each train passing through the block controlled by it, and then only on condition that the signal of the next succeeding block is restored to danger behind the previous train. Formerly the train worked a treadle, but the latter suffered from the heavy blows. Now the "track circuit" is used. Two insulated parallel rails form an independent circuit with a small Daniell gravity battery and a relay. When a

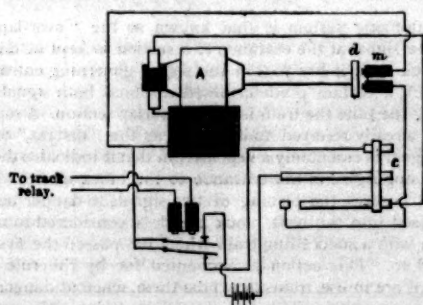
train passes the current is diverted from the relay, and the tongue of the latter influences the signal circuit. There is special mechanism by which the lever of, say, "A's" signal is locked in the danger position by the armature of an electromagnet controlled and operated by "B." A special circuit is erected between those points for the operation of the apparatus, and at each place an indicator is provided, which shows "clear" when neither has given permission to lower the other's signal, and "blocked" when one of them has done so. At "A" the special circuit includes the electromagnet only, the armature of which locks the signal lever. At "B" the circuit is completed through the tongue of a relay operated by the track circuit relay, and also through a "plunger" or circuit breaker. The effect of "plunging" is to break down the special circuit by which the lock is operated, and it remains in this condition until the train signalled passes on to the track circuit, which, of course, is outside of the "block." Until the train has passed on to the track circuit, and remade the locking circuit, further use of the plunger has no effect, and the operator at "B" is thus prevented from releasing "A's" signal for a second train, even if he inadvertently goes through the operation of plunging.

A purely automatic system is that known as the "over-lap." In this arrangement the signal at the entrance to a section is kept at danger by the train in the block until it has passed the signal governing entrance into the succeeding block, a certain predetermined distance, both signals being held at danger during the time the train is on the overlap section. A supplementary signal to those already referred to is known as the "distant," or cautionary signal. This signal is essentially a repeater, in that it indicates the position of the "home" or stop signal at the entrance to the block ahead. The overlap system, since it ensures the placing of two signals to danger behind a train after it has passed into the next block ahead, is considered to minimise the risk of collision with a succeeding train which has passed the first of the two signals referred to. This action is accounted for by the rule that, where automatic signals are in use, trains may pass them, when at danger, at caution, after a stop of one or more minutes, as the rule requires. Hence the overlap system enables two signals to be kept at danger behind the first train until the latter is some distance within the protection of the last one. The disadvantage is that drivers may be tempted to pass signals carelessly when at danger, when aware that the previous train may be actually out of the block governed by the signal.

In the most recent practice signals are operated by compressed air, separately provided and supplied, as in the Westinghouse system; or by electric motors, as in the Hall system. In the former the track relay governs the valves of a compressed-air motor through the medium of an electromagnet. The positive action of the motor duly lowers the arm. It is returned to danger by means of a counterweight. The Hall system provides for the operation of "distant," "home," and advanced or starting signals in places where it is desirable to draw a train forward for shunting or other purposes before the block ahead is clear of the preceding train. Besides this, warning bells are provided at all switches in a section. Signals are operated by electric motors of about $\frac{1}{4}$ h.p. The motor is attached to the signal above the counterweight, which it works by means of a stranded wire cable, the other end of which is attached to a drum in gear with the armature shaft, so as to effect a reduction of speed in the ratio of 25 to 1. The arrangements are shewn in the accompanying diagram. A is the motor, *m* a magnetic brake acting upon an iron disc, *d*, attached to the armature shaft, and *c* is a com-

mutator for altering the circuits automatically. The commutator is driven by a worm and gearing on the drum shaft. When the relay is first energised, the commutator is as shown, and current passes through the motor, which lowers the arm. As the motor runs, the commutator changes the circuits, in effect, as if the vertical passed gradually to the opposite end, breaking the motor circuits, and passing the current from the battery through the brake coils—which are of high resistance and take comparatively little current—instead. The magnetic brake draws up the motor, and holds it after the signal arm has been lowered. The signal is raised to danger again, when the armature of the relay is released, by the counterweight, and the commutator resumes the position shown by the rotation of the armature under the action of the counterweight. In this position of the commutator the motor circuit is short-circuited as long as the relay is not energised. Hence the current, generated by rotation of the motor armature by the falling counterweight, acts as a brake, and ensures the signal taking its position without undue shock.

Attempts have been made to cause a signal to physically prevent the entrance of a train into a block already occupied, by independent operation



of the air-brake; for instance, by a glass tube above the engine, which is broken by the impact of an arm projecting from the signal, or by a special projection on the track being made to close the throttle valve; but they have not generally met with success.

Methods and systems of signalling in use in this country:—The essential difference between British and American methods consists in the control of the signalling. In the States, in the higher development of signalling, control is exercised by the train itself by virtue of its position. With trifling exceptions, the highest development in this country is comparable only with the controlled manual in America. There are reasons why the use of automatic signalling should be more pronounced in the United States than in this country. Automatic signalling, whilst the ideal system for lines where long distances have to be run between diverging points, fails in that it exercises no selective action, and is therefore unsuitable for use at junctions. In this country junctions are numerous, and the operations at such points must necessarily be selective. There are, however, many places where automatic signalling might be used, though they do not necessarily form consecutive sections. E. O. W.

254. *Electrolysis by Earth Returns.* W. Leybold. (Elect. Rev. 49. pp. 492-498, Sept. 20, 1901. Paper read before the Glasgow Engineering

Congress.)—Electric currents were detected in water pipes near Durlach, 6 kilometres from the nearest generating-station, which were certainly not due to external influences. Such currents can only be due to voltaic action between the iron and the lead which is used for jointing. The author gives an account of the destruction of gas pipes at Hamburg, where the ground contains 0.0008 to 0.04 per cent. of sodium chloride. The electric trams were started in 1894, and were completed in 1895. In the latter year, corrosion of the wrought-iron pipes was discovered at points where they passed under the rails. The 1-inch pipes are covered with canvas soaked in boiled tar, but this method of protection does not seem to be very effective; in fact it favours the corrosion when once this has begun, because blisters form between the iron and the tar, containing saline liquid which is favourable to electrolysis. No corrosion has been observed in the pipes of cast-iron. The destruction has been remedied by laying down return-feeders which have reduced the pressure between the rails and the gas pipes in one of the streets from 5 volts to 0.45 volt.

W. R. C.

255. *Long Runs of Electric Automobiles.* H. F. Joel. (Elect. Rev. 49. pp. 864-865, Nov. 22, 1901.)—A table is given of six recorded runs on one charge, concluding with the recent run of 190 miles of a Krieger car with Fulmen cells. According to the figures given the weight of the cars ranged between 1 and 2.5 tons; the weight of the battery relatively to the total weight, from under 40 per cent. to a little over 50 per cent.; the useful load, i.e., passengers, relatively to total weight, from 10 per cent. to 20 per cent.; and the watt-hours used per ton-mile from 115 to 140. The figures relating to each run are discussed in some detail, and the author expresses the opinion that the most economical distribution of the total weight of a loaded car should be as follows: Car body, motor, &c., one-third; batteries one-third, and one-third for passengers or load. He calculates that under such conditions the cost for current would be one penny per ton-mile of useful load, with electrical energy at threepence per unit.

E. J. W.

ELECTRIC LAMPS AND LIGHTING.

256. *Czeczowiczka's Lighting System.* J. Löwy. (Zeitschr. Elektrotechn., Wien, 19. pp. 508-505, Oct. 20, 1901.)—In this system, which requires the network for supplying private consumers to be separated from that for the street-lighting, the lamps which are to burn all night, and those which are only to burn for the first half of the night, can be arranged on the same circuits, and the half-night lamps extinguished from the central station without it being necessary to employ a separate controlling circuit or a special switch. This is effected, according to one method, by arranging the lamps which are only to burn during the first half of the night in series with choking coils, the lamps which are to burn all night being connected directly across the mains. By supplying a direct current to the mains up to midnight, and an alternating current after midnight, the half-night lamps can be extinguished as required. The dimensions of the choking coils are calculated in the paper so as to give a mean loss per lamp of slightly over 5 per cent., distributing the loss over the whole time of lighting. An alternative method is given in which an alternating current is used first, condensers being arranged in series with the half-night lamps. Suitable central-station arrangements are also discussed.

C. K. F.

257. Arc Lighting. W. D'A. Ryan. (*Amer. Electn.* 18, pp. 522-524, Nov., 1901.)—The candle-power of arc lamps is expressed in several ways, including, amongst others, the mean c.p., the mean hemispherical c.p. (the lower hemisphere), and the mean c.p. over a selected area. Such ratings are of little use for determining the commercial illuminating value of lamps for street-lighting purposes.

Street illumination curves are given in the paper, plotted from measurements taken with direct current open and enclosed arcs, and an enclosed alternating arc.

The curves show the intensity of illumination which will fall on objects normal to the rays of light at different distances from the pole.

The peculiarities of open, enclosed, and alternating lamps are compared, and candle-power curves given which show the variations in c.p. from the time of striking to the feeding point.

The greatest variations are in the open arc, the following figures being a summary of results on which the curves are based. The c.p.s given are the maximum.

Conditions.	Open Arc.	Enclosed Arc.
Hissing arc over-feeding	800 c.p.	—
Short arc just after striking	600 "	525 c.p.
Normal arc	1,250 "	600 "
Long arc just before feeding	1,400 "	570 "

Better distribution also is obtained with enclosed arcs, and there is not that excess of light nor dense shadow common to the open type.

Curves of distribution of illumination are given, based upon various sizes of street lamps, of the alternating enclosed type. A certain degree of illumination, as determined by a luminometer, was fixed upon as a minimum midway between the two lamps. Tests were then made with various lamps to ascertain the distance D, to which this illumination could be projected. The curves are based on the following figures:—

Current and Energy per Lamp.	D.	Lamps per Mile.	Watts per Mile.	Size of Carbon.
7.5 amp. (485 W.)	247 feet	10.68	5,180	$\frac{1}{2}$ inch
6.6 " (425 ")	227 "	11.62	4,940	$\frac{3}{8}$ "
5.4 " (350 ")	197 "	13.40	4,690	$\frac{1}{4}$ "
4.4 " (285 ")	178 "	14.85	4,235	$\frac{1}{8}$ "

The distance apart of two lamps is of course double that given in the distance column. F. B.

258. Regulating Devices for Series Alternating Current Circuits. J. H. Hallberg. (*West. Electn.* 29, pp. 272-278, Oct. 26; and pp. 288-289, Nov. 2, 1901. Paper read before the Ohio Electric Light Assoc., Aug. 21, 1901, at Put-in-Bay.)—A general description is given of regulating devices for arc lamps run in series on an alternating current circuit. A detailed practical account is also given of the series alternating current system with compensators and shunt wound enclosed arc lamps. The author divides alternating current enclosed arc lamp series systems into three classes. In the first class differentially wound arc lamps are used, equipped with automatic cut-outs, and hand and automatic switches are employed which bring in and cut out choking coils for equalising the pressure. This is not

a practical method when more than twelve lamps have to be operated in series. Sometimes a transformer is used, with terminals on its secondary coil giving various potentials, so that the pressure in the circuit can be varied by a hand switch. This system is complicated, and the regulation is not good. In the second class a constant current transformer is employed, the secondary being generally a floating coil counterpoised by a weight. The change of pressure is effected automatically by the repulsion between the primary and secondary coils. In this system it is necessary to use differentially wound arc lamps. The efficiency of these lamps is stated to be about 90 per cent., and that of the 100-light (about 60 kw.) constant current transformer generally employed, about 96 per cent. This system is limited to cases where the circuits are practically always fully loaded. Sometimes the constant current transformer has a device actuated by any change in the secondary current, which cuts in or out turns in the secondary so as always to maintain the proper p.d. in the lamp circuit. The power factor and current are practically constant at all loads, and the efficiency of a 50 or 100 light circuit is about 87.5 per cent. In the third system compensating choking coils are used in series, and shunt wound enclosed arc lamps are found to be the most suitable. A full description is given of a "G. I." automatic regulator for this circuit. Its efficiency is 98.8 per cent., and it regulates to within 0.2 of an ampere. The author considers that this system is the most economical. He says that experiments are being made with condensers to try and increase the power factor of arc-lamp circuits.

A. R.

REFERENCES.

259. *Determination of Price of Electric Supply.* **K. Wilkens.** (Elektrotechn. Zeitschr. 22. pp. 1001-1003, Dec. 5, 1901.)—This is a supplement to the paper referred to in Abstract No. 1199 (1901) and describes how the quantities required by the equation there given can be determined in practice. Examples of the different classes of consumers are given.

C. K. F.

260. *Electric Tramway Tractive Effort and Power Diagram.* **A. G. Hansard.** (Electrician, 47. p. 937, Oct. 11, 1901.)—A description of its use accompanies the diagram, which enables the following information to be obtained by inspection:—
1. Given the weight of the car and the gradient, the "drawbar pull" is shown.
2. Taking into account the speed, the brake horse-power required to drive the car may be found.
3. If the efficiency of the electrical equipment is known, the kilowatts to be supplied to the motors are shown.

261. *Best Form of Car for City Service.* **E. Chamberlin.** (Street Rly. Journ. 18. pp. 465-468, Nov., 1901. Paper read before the American Street Railway Association.)

262. *Tests of Nernst Lamps.* (Elect. Engin. 28. pp. 726-728, Nov. 22, and pp. 765-767, Nov. 29, 1901. Translation.)

263. *Storage Batteries for Automobiles.* (Elect. World and Engineer, 38. pp. 538-546, Oct. 5, 1901.)—This paper consists of an illustrated description of various types of American accumulators specially intended for use in autocars. In most cases some account is given of their design and method of manufacture, curves of discharge p.d. and figures of output for weight. The following makes are dealt with: Sperry, Clare, Perret, Gould, Chloride, Willard, Porter, American, Reuterdales, and Osburn.

E. J. W.

TELEGRAPHY AND TELEPHONY.

264. Cable Speed-Rate Conversion Tables. E. Raymond-Barker. (Elect. Rev. 49. pp. 865-867, Nov. 22, 1901.)—Tables of multipliers by which statements of telegraphic speed, whether in siphon recorder or in Morse code, may be reduced from one mode of expression to another with due regard to the varying space factor. A formula is constructed and forms the basis for the tables as follows:—The element (e) is the fundamental unit, where each contact (siphon recorder) = $1e$, each dot (Morse) = $1e$, each dash (Morse) = $3e$, each space between contacts = $1e$, and each space between words = $7e$. The number of elements per letter, denoted by v , has for traffic purposes been shown to be 7.16 for recorder, and 9.12 for international Morse. And x , the number of words of N letters signalled per minute, being equal to the ratio of the number of elements signalled per minute, to the number of elements per word of N letters, allowing for spaces between letters and words, is determined from the following equation, in which W is the number of words, and L the number of letters received in T minutes:—

$$x = \frac{\{Lv + 4(W - 1)\} \frac{1}{T}}{vN + \frac{4}{vN}}$$

For practical purposes, a sufficiently close approximation is obtained by writing—

$$x = \frac{(Lv + 4W) \frac{1}{T}}{vN + \frac{4}{vN}}$$

E. O. W.

265. Induction Troubles in Telephone Cables. J. H. West. (Elektrotechn. Zeitschr. 22. p. 829, Oct. 8, 1901.)—The author investigates the induction troubles which occurred in the London and Birmingham telephone cables having two pairs of cores laid or twisted together, and attributes them to the several cores being unequally braked or stretched during the twisting; for example, three of them may be wound spirally round the fourth, which is the most tightly stretched. He makes the following suggestions: (1) That the drums should rotate as easily as possible, and that the twist should be as long as is permitted in view of the flexibility which the wires and cable must have during the manufacture and laying; (2) that, at definite intervals, the wires of one loop should be interchanged when necessary, or all the four wires interchanged; (3) that successive lengths of cable should be alternately twisted right- and left-handedly, and also that, in cables with 400-500 wires, the connections of the several lengths should only be temporarily made at certain places, so that the wires can be interchanged, and so eliminate any induction troubles that may be found to exist.

C. K. F.